

HYDRAULIC AND SCOUR ANALYSES FOR THE QUARRY CREEK BRIDGE (C.T. 11-04)

October 3, 2012



A handwritten signature of "Wayne W. Chang" in black ink.

Wayne W. Chang, MS, PE 46548

Chang Consultants
Civil Engineering • Hydrology • Hydraulics • Sedimentation

**P.O. Box 9496
Rancho Santa Fe, CA 92067
(858) 692-0760**

TABLE OF CONTENTS

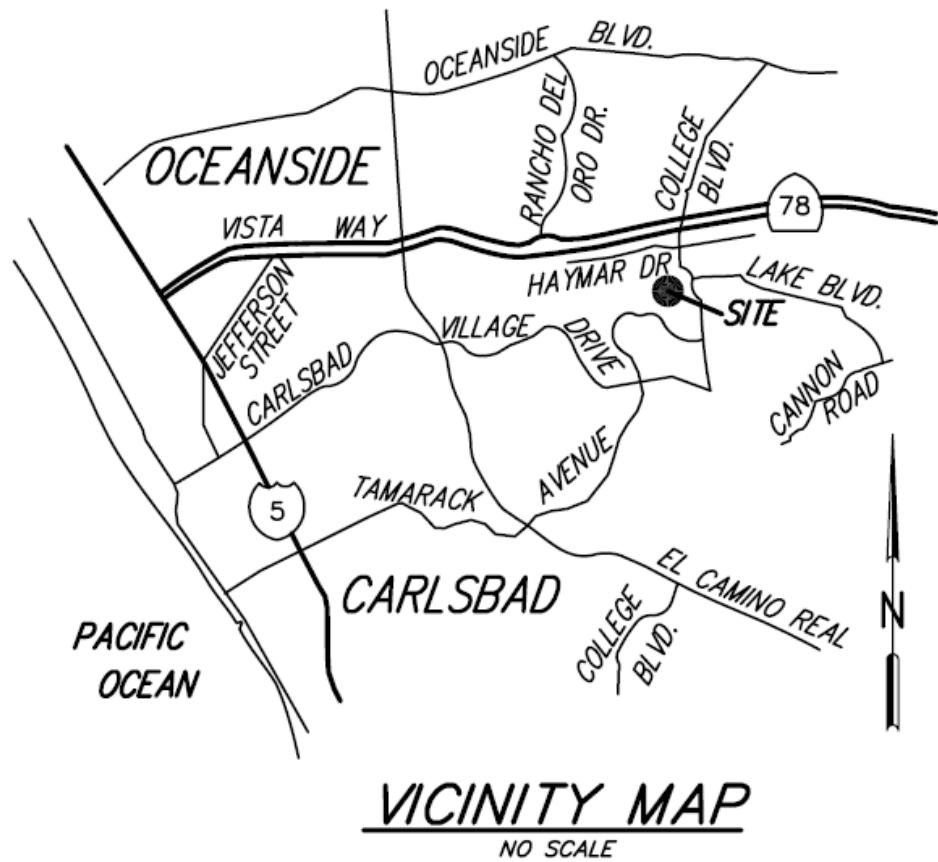
Introduction.....	1
Bridge Analyses	2
Conclusion	4

APPENDICES

- A. 100-Year HEC-RAS Analyses without Bridge
- B. 100-Year HEC-RAS Analyses with Bridge

INTRODUCTION

McMillin Land Development's (McMillin) Quarry Creek project site is located south of Haymar Drive and west of College Boulevard in the cities of Carlsbad and Oceanside, California (see Vicinity Map). A portion of the project will be within Hanson Aggregates Pacific Southwest Inc.'s (Hanson) South Coast Materials Quarry. Reclamation of the Hanson site was recently approved by the Cities of Carlsbad (SUP 07-03 and Drawing No. 470-5A) and Oceanside (RMA-1-2001 Revision 05 and Drawing No. G11-0002). The McMillin project will not proceed until Hanson's reclamation grading is complete.



Hanson's reclamation grading will result in channelization of Buena Vista Creek within the site. The channelization will create a vegetated trapezoidal channel with a 150-foot bottom width, 2.5 to 1 side slopes, a terrace along each channel bank, and seven riprap drop structures. Three existing bridge crossings have been removed as part of reclamation.

McMillin's project grading is being designed by Project Design Consultants. PDC's grading will not alter the physical channel constructed by reclamation. However, a bridge crossing by TY Lin International will be added near the downstream end of the channel. The proposed bridge is identified as Alternative 2B (see plan contained after this report text) and will contain two 3-foot wide piers. This report contains hydraulic and local scour analyses for the proposed bridge for entitlement purposes.

BRIDGE ANALYSES

HEC-RAS analyses were used to design the proposed channel associated with Hanson's reclamation. The analyses are included in both Chang Consultants' May 26, 2011, *Drainage Report for South Coast Materials Quarry*, approved by the City of Carlsbad and Chang Consultants' March 9, 2011, *Drainage Report for Hanson Aggregates Quarry*, approved by the City of Oceanside. The analyses are included in Appendix A and a HEC-RAS Work Map is included after this report text. The following paragraph summarizes the previous analyses from the reports.

A 100-year HEC-RAS analysis was performed to design a channel that minimizes erosive flow velocities. The 100-year flow rate of 10,800 cubic feet per second was determined in a June 23, 1994 report by Hunsaker & Associates San Diego, Inc. titled *Hydrologic Study for Buena Vista Creek Basin*. The report was prepared for the City of Oceanside and states that "this report analyzes the Buena Vista Creek Basin in its ultimate condition." A low roughness coefficient of 0.030 was assumed, which is conservative from a velocity standpoint. The analysis determined that the proposed trapezoidal channel with a 150-foot bottom width, 2.5 to 1 side slopes, and terraces was appropriate. The graded channel bed areas between drops will generally be sloped at 0.14 percent. The channel was narrowed as it approaches a drop structure in order to create a backwater situation that will reduce the upstream flow velocities. The riprap below each drop structure was extended beyond the hydraulic jump shown in the HEC-RAS analysis. A second HEC-RAS analysis was performed on the proposed channel design assuming a high roughness coefficient of 0.10. This analysis was used to establish the minimum pad elevations. The pads were designed with at least a foot of freeboard above the 100-year water surface elevations.

Debris was not included in the hydraulic modeling of the bridge piers. The creek channel was designed with non-erosive velocities in the vegetated areas even under a low roughness condition. Therefore, the potential for vegetation removal by flow events has been minimized. In addition, the channel in a high roughness condition has approximatley 20 feet of freeboard during a 100-year event near the proposed bridge. Therefore, the channel has ample capacity even if debris collects on the piers. A high roughness coefficient has been used in the analyses, which to some degree accounts for debris. Finally, the Federal Emergency Management Agency does not require debris to be modeled in their floodplain mapping. Based on this information, modeling debris on the piers would not be a relevant factor in ensuring adequate channel capacity near the proposed bridge.

For this report, the previous high and low roughness coefficient analyses were modified to include the Alternative 2B bridge crossing. The bridge is located between HEC-RAS cross-sections 3.774 and 3.792. The other portions of the analyses were unaltered. The results are included in Appendix B. A comparison of the high roughness coefficient HEC-RAS results near the bridge is summarized in Table 1. The results show that the water surface elevations with and without the bridge match downstream of the bridge and at cross-section 3.846. The maximum rise in the 100-year water surface elevations between these locations due to the bridge is 0.2 feet. The channel has several feet of freeboard, so this small rise is acceptable.

Cross-Section	100-Year Water Surface Elevation without Bridge, ft	100-Year Water Surface Elevation with Bridge, ft
3.774 (Downstream of Bridge)	84.5	84.5
3.792 (Upstream of Bridge)	85.7	85.9
3.808	86.1	86.3
3.825	86.5	86.7
3.827	86.4	86.6
3.828	85.8	86.0
3.830	86.6	86.7
3.838	88.0	88.1
3.846	88.3	88.3

Table 1. Comparison of HEC-RAS Results near Bridge

The bridge design should also consider scour. Stream bed scour consists of general scour, contraction scour, and local scour. General scour is related to the sediment supplied into and transported out of a channel reach. Contraction scour is associated with the increased flow velocities associated with narrowing of a watercourse. Local scour is due to a local flow obstruction by a bridge pier/bent or abutment. The total scour is the general scour, contraction scour, plus the local scour. In this case, the drop structures will stabilize the channel bed at the bridge so that general scour will not occur. The channel near the proposed bridge is fairly uniform in width although there is a contraction at the drop structures in order to create backwater, as mentioned above. However, the drop structures are lined with riprap, which will prevent contraction scour. Furthermore, the abutments will be above the 100-year water surface elevations, so abutment scour will not be a concern.

Local scour analyses were performed to determine the pier scour, which is associated with accelerated flow and the resulting vortices leading to a removal of material near a bridge pier. The Colorado State University (CSU) equation from the Hydraulic Engineering Circular No. 18 (HEC-18) is the standard pier scour formula and has the following form:

$$y_s/a = 2.0 K_1 K_2 K_3 K_4 (y_1/a)^{0.35} F_r^{0.43}$$

where,

y_s = scour depth, feet

y_1 = flow depth directly upstream of the pier, feet

a = pier width

K_1 = correction factor for pier nose shape

K_2 = correction factor for angle of attack of flow

K_3 = correction factor for bed condition

K_4 = correction factor for armoring by bed material size

F_r = Froude number directly upstream of pier

The CSU equation input values are: y_1 = flow depth from the HEC-RAS results at cross-section 3.792, a = 3 feet, K_1 = 1.0 for round nose pier, K_2 = 1.0 for no angle of attack, K_3 = 1.1 for a

plane bed, $K_4 = 1.0$ for no bed armoring, and F_r = Froude number from the HEC-RAS results at cross-section 3.792. Table 3 summarizes the pier scour input and results for the high and low roughness HEC-RAS analyses. The table indicates that the pier scour will be greater under a low channel roughness. The piers shall be designed for the 6.6 feet of local scour.

Condition	y_1 , ft	A, ft	F_r	y_s , ft
Low Roughness	10.3	3	0.36	6.6
High Roughness	12.6	3	0.25	6.0

Note: $K_1=1.0$, $K_2 = 1.0$, $K_3 = 1.1$, and $K_4 = 1.0$ for all cases.

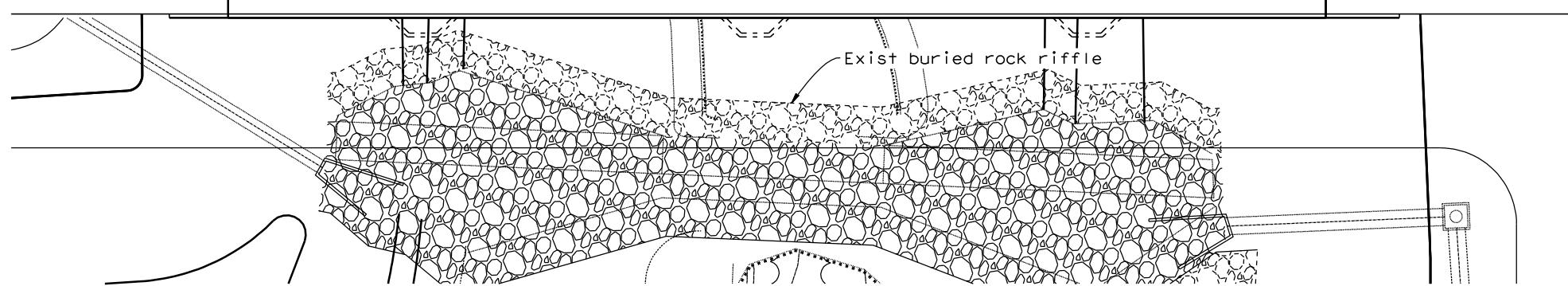
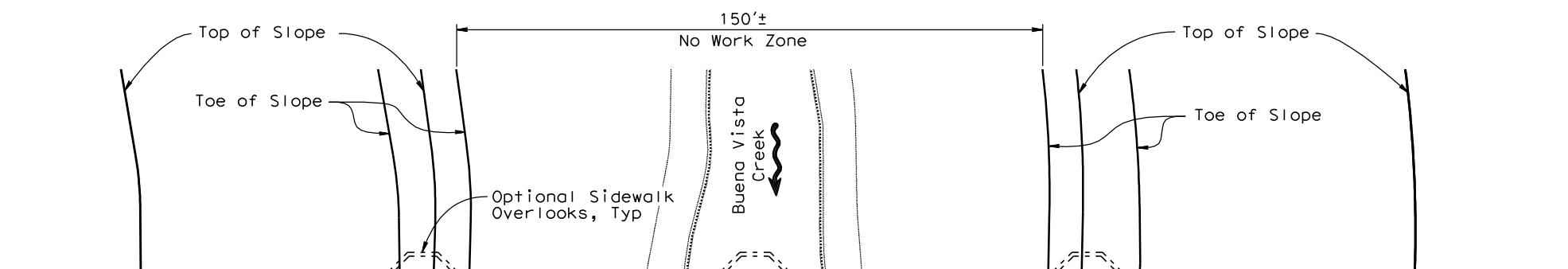
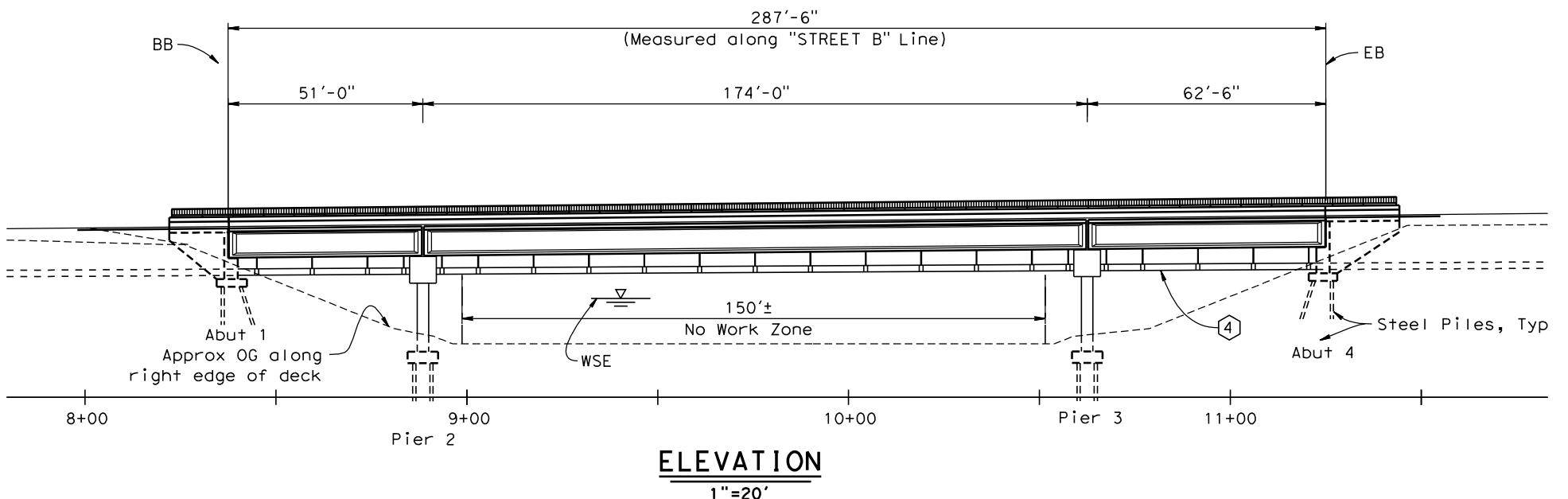
Table 3. Summary of Pier Scour

CONCLUSION

Hydraulic and scour analyses have been performed for the proposed Alternative 2B bridge for McMillin's Quarry Creek development. The results indicate that the bridge will cause a small increase in 100-year water surface elevations. The proposed 100-year floodplain has been plotted on the work map included after this report text and shows that there is sufficient freeboard near the bridge location so the slight rise is acceptable.

Up to 6.6 feet of pier scour is predicted at each of the two piers. Each pier shall be designed to account for this scour. The scour zone should also be assessed in detail during final engineering to verify that it will not impact the adjacent drop structure or to provide appropriate mitigation.

A 100-year floodway and floodplain have been mapped for this segment of Buena Vista Creek by the Federal Emergency Management Agency (*Flood Insurance Rate Map* No. 06073C0766G dated May 16, 2012). Since the proposed bridge will have an impact on water surface elevations, a Conditional Letter of Map Revision and Letter of Map Revision will need to be processed through FEMA to reflect the updated floodway and floodplain resulting from the bridge. The freeboard near the proposed bridge under the 100-year flows is nearly 20 feet. The minor increases in water surface elevation associated with the project will be contained within the on-site channel with more than adequate freeboard and will not impact off-site properties. Therefore, the proposed bridge will be in compliance with FEMA regulations. The hydraulic analyses submitted with the CLOMR and LOMR will tie into the existing FEMA analysis at the upstream and downstream ends of the new study reach. The CLOMR is typically processed after the engineering drawings have been prepared and used to obtain FEMA's conditional approval of the floodplain and floodway revisions associated with a project. The LOMR is processed after the project is complete and used to officially revise the floodway and floodplain. Based on the minor impacts to water surface elevations shown by the analyses performed to-date, the 100-year floodplain and floodway near the bridge will be contained within the creek channel with ample freeboard. Therefore, the project will be in compliance with FEMA regulations outlined in the Code of Federal Regulations.



PLAN

1"=20'

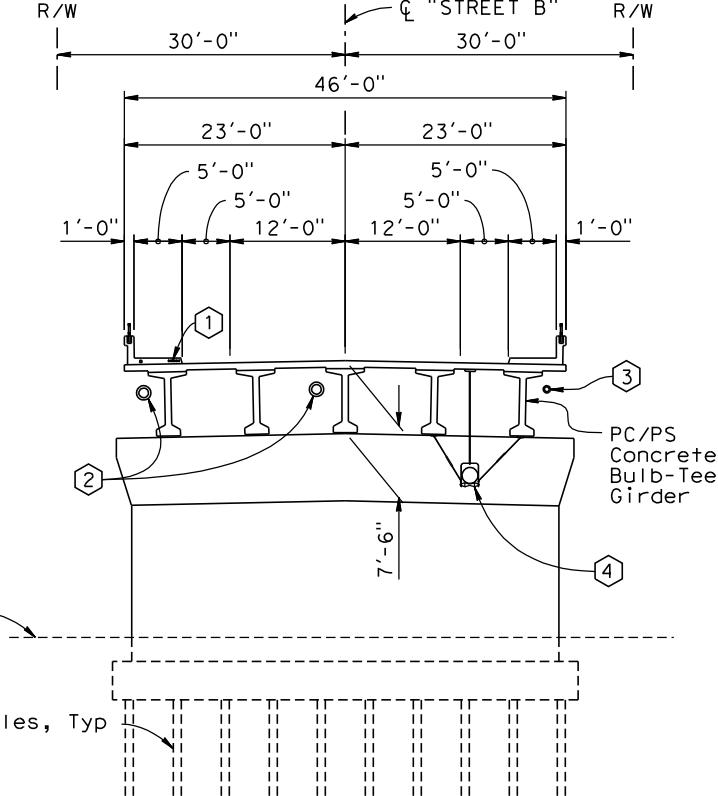
TYLIN INTERNATIONAL
404 CAMINO DEL RIO SOUTH, SUITE 700, SAN DIEGO, CA. 92108
(619) 692-1920 www.tylin.com

CITY APPROVED CHANGES

NO.	DESCRIPTION	APPROVED BY	DATE

BENCH MARK:

DESCRIPTION: _____
LOCATION: _____
RECORD FROM: _____ ELEV: _____ DATUM: _____



TYPICAL SECTION

UTILITIES

- ① - Dry Utilities
- ② - 12" Water
- ③ - 6" Reclaimed Water
- ④ - 12" Sewer in 18" casing

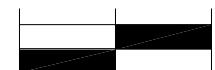
SHEET 13	CITY OF OCEANSIDE ENGINEERING DEPARTMENT	13 SHEETS
PLANS FOR		
QUARRY CREEK BRIDGE		
PLANNING STUDY		
APPROVED		
CITY ENGINEER		
ENGINEER OF WORK	CHECKED BY	DRAWN BY
R.C.E.	APPROVAL DATE	

NOTE:

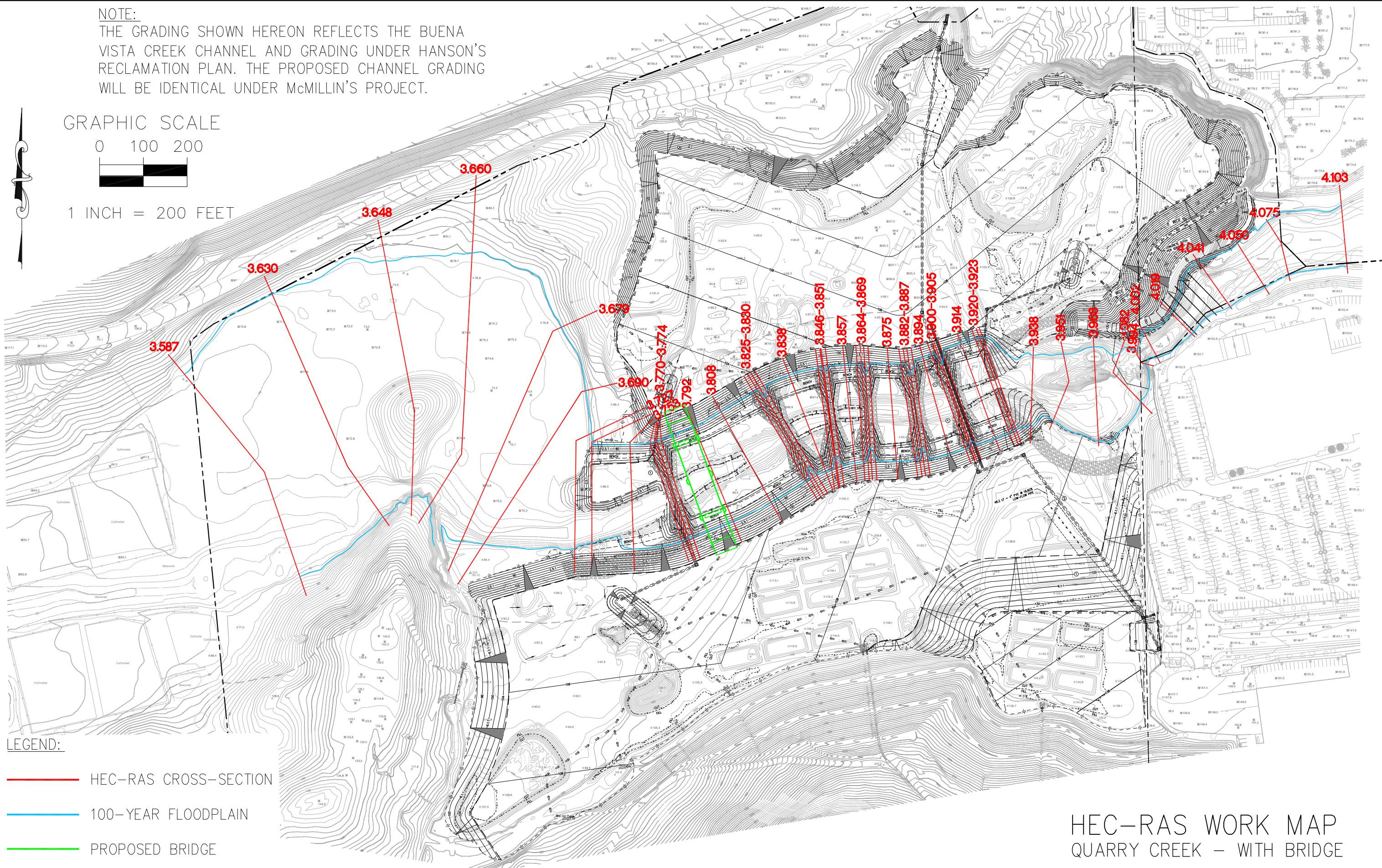
THE GRADING SHOWN HEREON REFLECTS THE BUENA VISTA CREEK CHANNEL AND GRADING UNDER HANSON'S RECLAMATION PLAN. THE PROPOSED CHANNEL GRADING WILL BE IDENTICAL UNDER McMILLIN'S PROJECT.

GRAPHIC SCALE

0 100 200



1 INCH = 200 FEET



APPENDIX A

100-YEAR HEC-RAS ANALYSES

WITHOUT BRIDGE

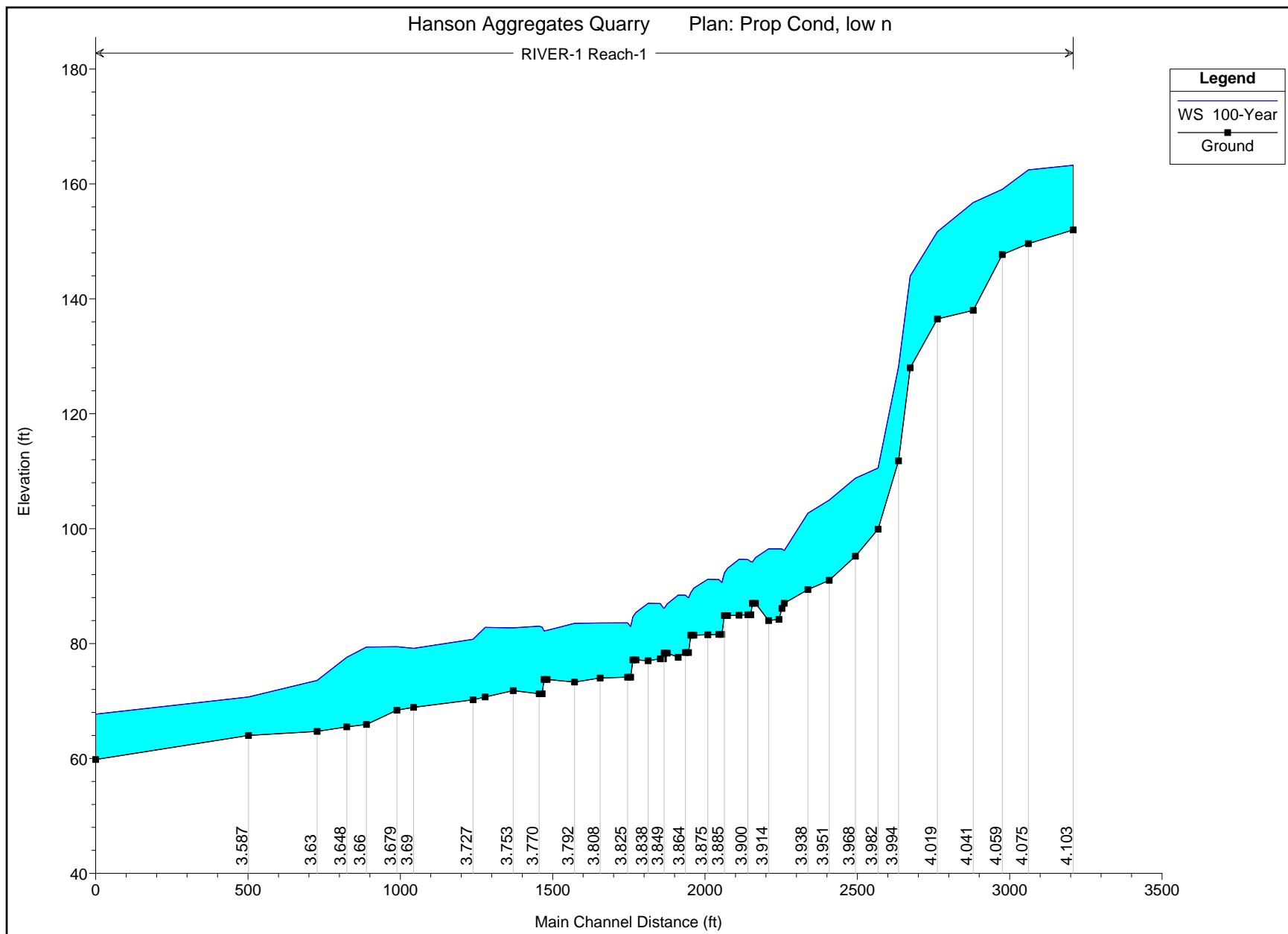
AMENDED RECLAMATION PLAN LOW CHANNEL ROUGHNESS ANALYSIS

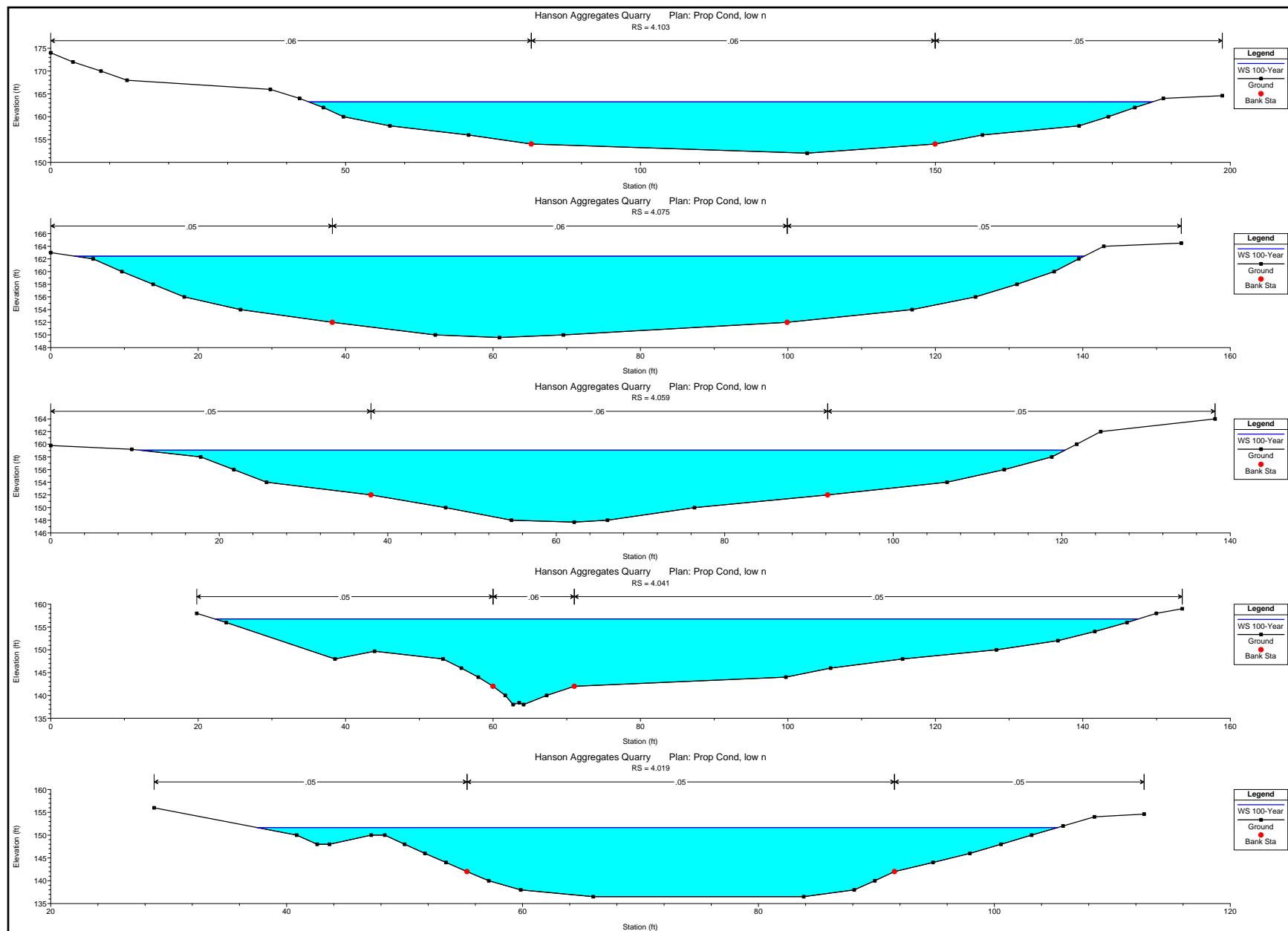
HEC-RAS Plan: PC low n River: RIVER-1 Reach: Reach-1 Profile: 100-Year

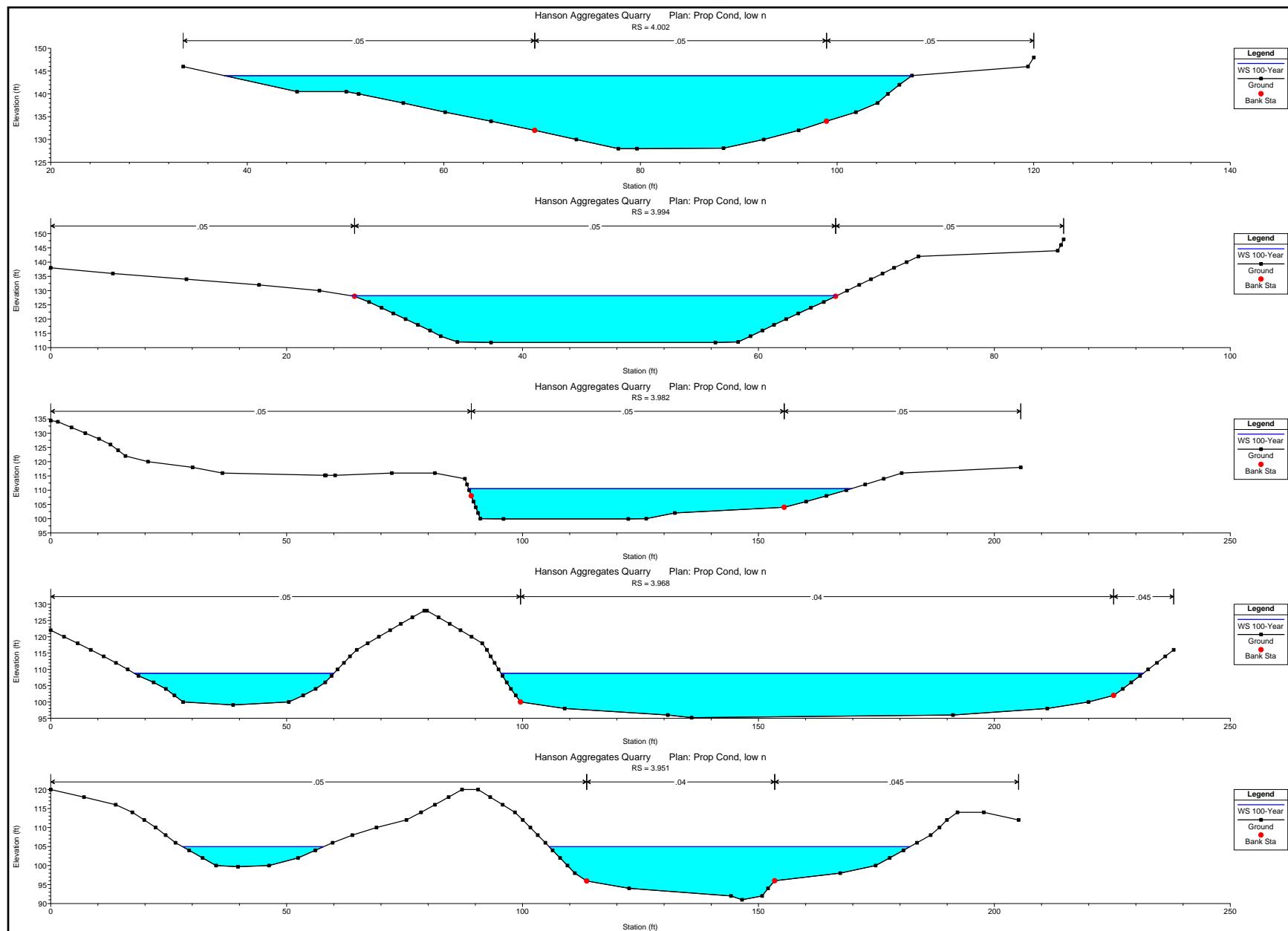
Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	3.492	100-Year	10800.00	59.80	67.71	67.01	68.33	0.004202	7.86	1901.22	595.42	0.57
Reach-1	3.587	100-Year	10800.00	64.00	70.70	70.70	71.99	0.009097	9.55	1316.24	519.39	0.80
Reach-1	3.63	100-Year	10800.00	64.70	73.59	73.59	74.76	0.006141	10.19	1536.90	560.76	0.70
Reach-1	3.648	100-Year	10800.00	65.50	77.61	77.61	79.22	0.010399	13.10	1155.11	314.46	0.82
Reach-1	3.66	100-Year	10800.00	65.90	79.39		79.65	0.001006	5.28	2934.94	591.64	0.30
Reach-1	3.679	100-Year	10800.00	68.40	79.46		79.92	0.002292	7.12	2208.87	537.48	0.44
Reach-1	3.69	100-Year	10800.00	68.90	79.16	79.12	80.49	0.007214	11.95	1379.35	416.97	0.77
Reach-1	3.727	100-Year	10800.00	70.20	80.74	80.74	82.97	0.004881	12.99	988.16	205.75	0.83
Reach-1	3.734	100-Year	10800.00	70.70	82.81		83.21	0.000564	5.12	2134.49	231.62	0.29
Reach-1	3.753	100-Year	10800.00	71.80	82.74		83.33	0.000865	5.74	1762.09	201.38	0.35
Reach-1	3.770	100-Year	10800.00	71.26	83.01		83.39	0.000454	4.94	2207.27	231.39	0.27
Reach-1	3.771	100-Year	10800.00	71.26	82.85		83.47	0.001069	6.32	1711.31	226.80	0.40
Reach-1	3.773	100-Year	10800.00	73.76	82.19		83.77	0.004357	10.07	1072.77	197.52	0.76
Reach-1	3.774	100-Year	10800.00	73.76	82.30		83.81	0.004144	9.88	1092.82	199.24	0.74
Reach-1	3.792	100-Year	10800.00	73.30	83.51		84.06	0.000918	5.96	1813.19	224.42	0.37
Reach-1	3.808	100-Year	10800.00	74.00	83.59		84.14	0.000895	5.94	1819.33	223.18	0.37
Reach-1	3.825	100-Year	10800.00	74.14	83.61		84.26	0.001182	6.50	1661.87	220.80	0.42
Reach-1	3.827	100-Year	10800.00	74.14	82.95		84.57	0.004186	10.21	1057.31	184.60	0.75
Reach-1	3.828	100-Year	10800.00	77.16	84.66	84.66	87.18	0.007718	12.75	847.21	167.94	1.00
Reach-1	3.830	100-Year	10800.00	77.16	85.44	84.66	87.31	0.005151	11.00	981.94	179.31	0.83
Reach-1	3.838	100-Year	10800.00	77.00	87.02		87.52	0.000814	5.69	1898.37	229.44	0.35
Reach-1	3.846	100-Year	10800.00	77.33	86.97		87.59	0.001120	6.33	1707.20	226.45	0.41
Reach-1	3.848	100-Year	10800.00	77.33	86.19		87.95	0.004583	10.65	1014.42	178.09	0.79
Reach-1	3.849	100-Year	10800.00	78.33	86.11	86.11	88.65	0.007715	12.77	845.44	167.01	1.00
Reach-1	3.851	100-Year	10800.00	78.33	86.90	86.11	88.78	0.005153	11.01	980.57	178.73	0.83
Reach-1	3.857	100-Year	10800.00	77.60	88.44		88.98	0.000869	5.88	1836.88	220.98	0.36
Reach-1	3.864	100-Year	10800.00	78.43	88.41		89.02	0.001044	6.30	1715.41	216.99	0.39
Reach-1	3.866	100-Year	10800.00	78.43	87.96		89.24	0.002971	9.07	1190.26	191.83	0.64
Reach-1	3.867	100-Year	10800.00	81.45	88.88	88.88	91.41	0.007744	12.77	845.92	167.72	1.00
Reach-1	3.869	100-Year	10800.00	81.45	89.66	88.88	91.54	0.005147	11.00	981.65	179.07	0.83
Reach-1	3.875	100-Year	10800.00	81.53	91.20		91.75	0.000857	5.96	1816.26	220.35	0.36
Reach-1	3.882	100-Year	10800.00	81.59	91.13		91.84	0.001263	6.73	1605.14	214.76	0.43
Reach-1	3.884	100-Year	10800.00	81.59	90.61		92.09	0.003700	9.77	1105.05	187.91	0.71
Reach-1	3.885	100-Year	10800.00	84.87	92.30	92.30	94.83	0.007750	12.76	846.49	168.10	1.00
Reach-1	3.887	100-Year	10800.00	84.87	93.08	92.30	94.96	0.005147	10.99	982.83	179.60	0.83
Reach-1	3.894	100-Year	10800.00	84.94	94.65		95.16	0.000811	5.72	1886.65	227.09	0.35
Reach-1	3.900	100-Year	10800.00	85.01	94.61		95.21	0.001019	6.20	1741.21	221.33	0.39
Reach-1	3.902	100-Year	10800.00	85.01	94.25		95.39	0.002677	8.55	1262.90	205.95	0.61

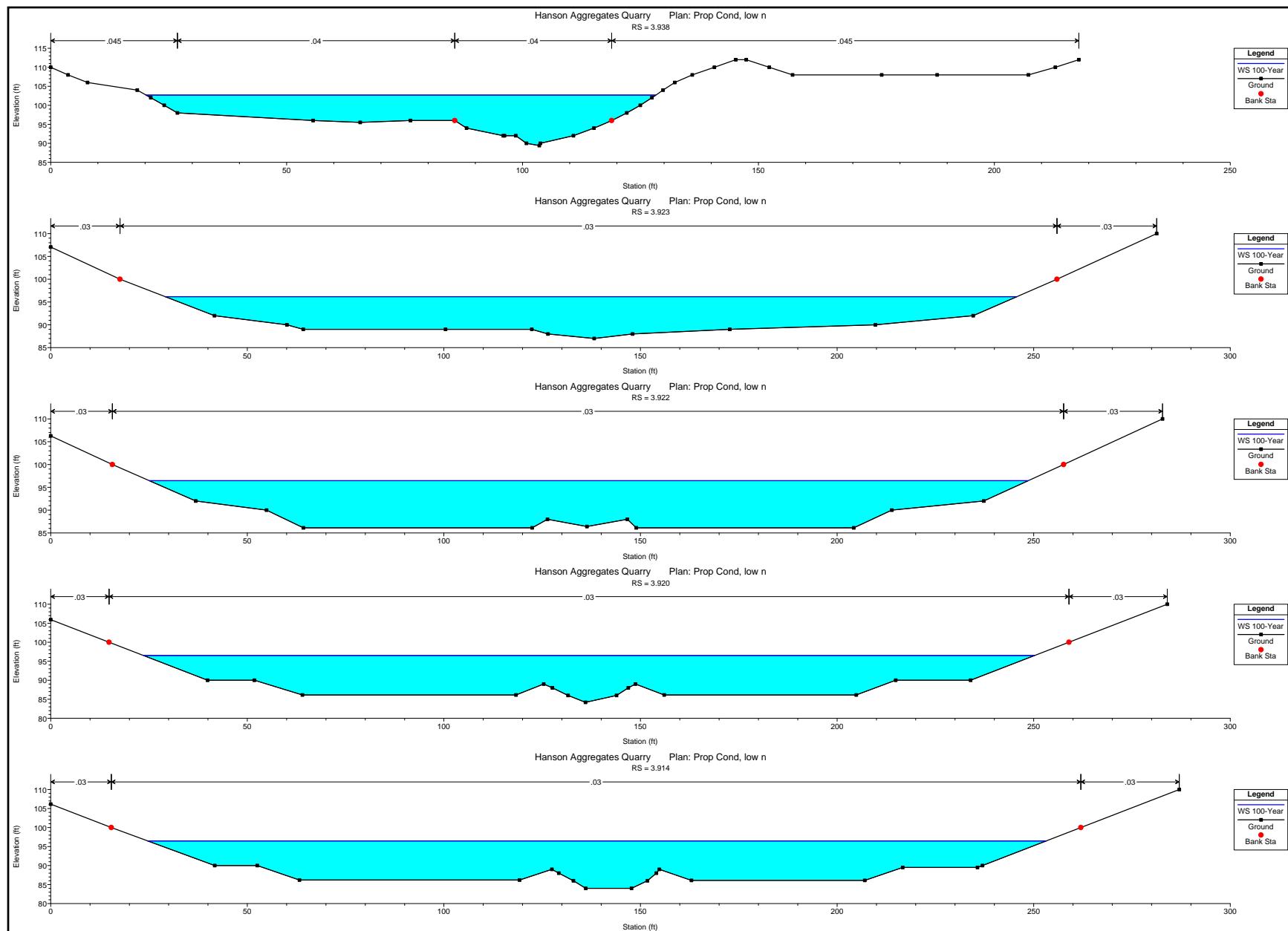
HEC-RAS Plan: PC low n River: RIVER-1 Reach: Reach-1 Profile: 100-Year (Continued)

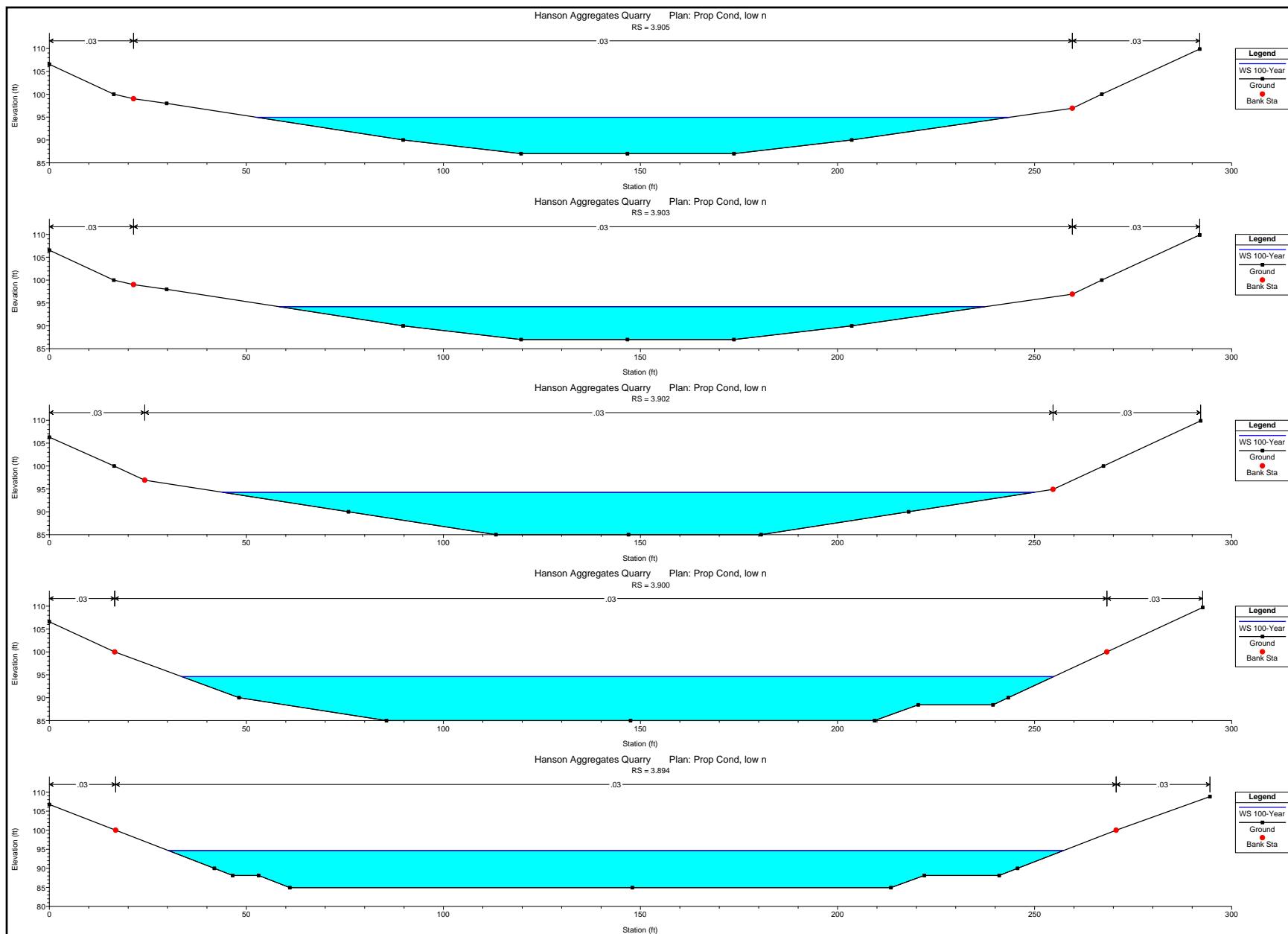
Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	3.903	100-Year	10800.00	87.01	94.19	94.19	96.61	0.007861	12.50	863.84	179.00	1.00
Reach-1	3.905	100-Year	10800.00	87.01	94.96	94.19	96.74	0.005155	10.73	1006.22	190.98	0.82
Reach-1	3.914	100-Year	10800.00	84.00	96.48		96.94	0.000717	5.46	1976.60	228.52	0.33
Reach-1	3.920	100-Year	10800.00	84.20	96.49		96.97	0.000764	5.60	1930.23	226.53	0.34
Reach-1	3.922	100-Year	10800.00	86.12	96.47		96.99	0.000839	5.81	1859.64	223.62	0.35
Reach-1	3.923	100-Year	10800.00	87.00	96.17		97.13	0.002175	7.86	1373.35	216.63	0.55
Reach-1	3.938	100-Year	10800.00	89.40	102.69	102.69	106.13	0.010441	16.77	759.17	108.01	0.92
Reach-1	3.951	100-Year	10800.00	91.00	104.96	104.96	108.84	0.009106	17.47	786.14	106.36	0.90
Reach-1	3.968	100-Year	10800.00	95.20	108.78		109.38	0.001117	6.47	1844.61	178.41	0.33
Reach-1	3.982	100-Year	10800.00	99.90	110.55	110.55	114.80	0.018461	16.79	667.64	81.15	0.97
Reach-1	3.994	100-Year	10800.00	111.80	128.19	128.19	134.66	0.025955	20.42	529.05	41.17	1.00
Reach-1	4.002	100-Year	10800.00	128.00	143.99	143.99	149.09	0.014008	19.76	658.68	69.90	0.92
Reach-1	4.019	100-Year	10800.00	136.50	151.68	151.68	156.80	0.013457	18.93	648.36	67.91	0.88
Reach-1	4.041	100-Year	10800.00	138.00	156.76	153.07	158.09	0.005242	9.84	1187.05	125.22	0.42
Reach-1	4.059	100-Year	10800.00	147.70	159.07	159.07	162.64	0.021998	16.20	739.15	109.91	0.93
Reach-1	4.075	100-Year	10800.00	149.60	162.44		163.70	0.005696	9.65	1221.90	136.99	0.50
Reach-1	4.103	100-Year	10800.00	152.00	163.26		164.81	0.008583	10.82	1118.10	143.15	0.60

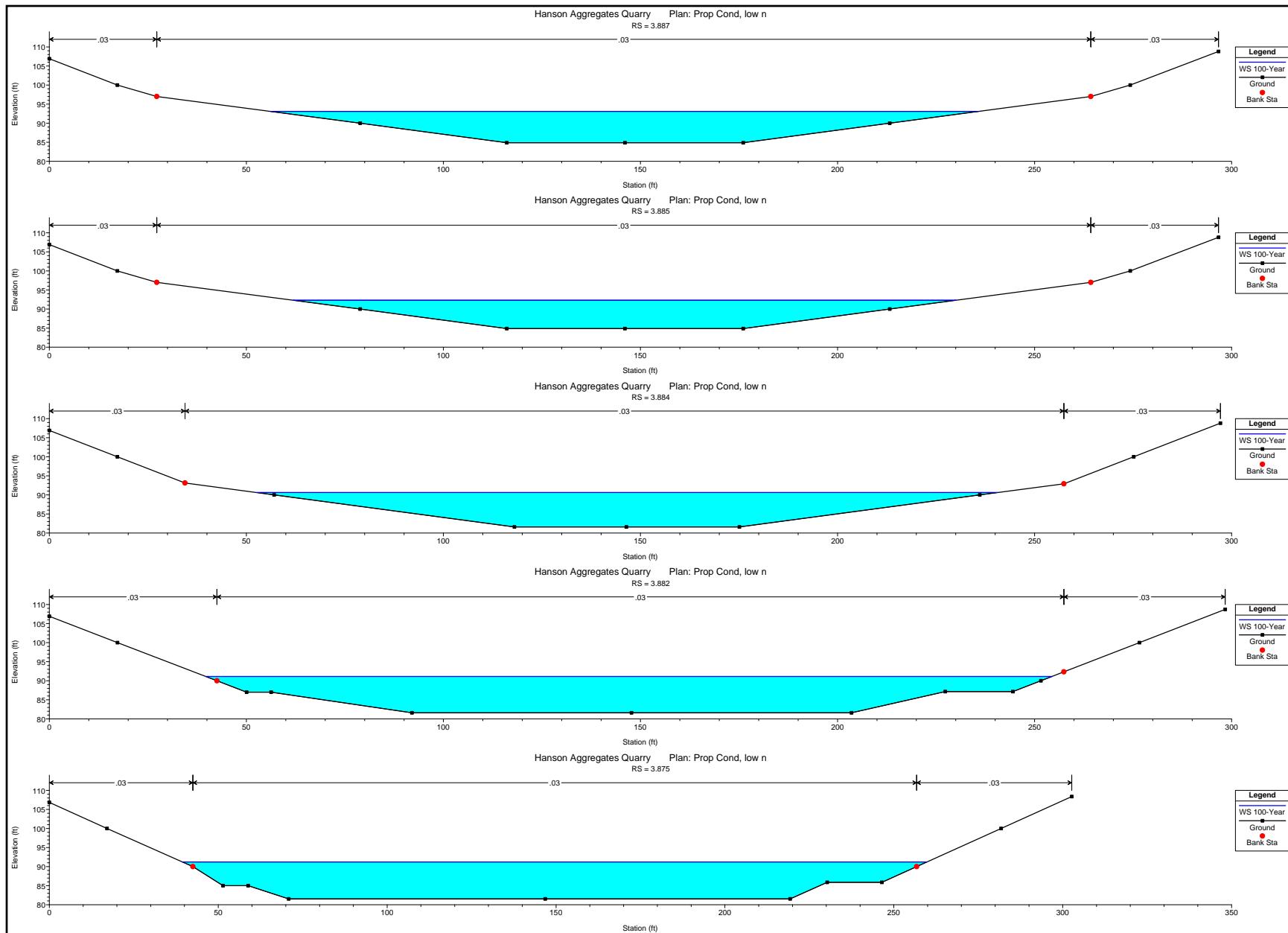


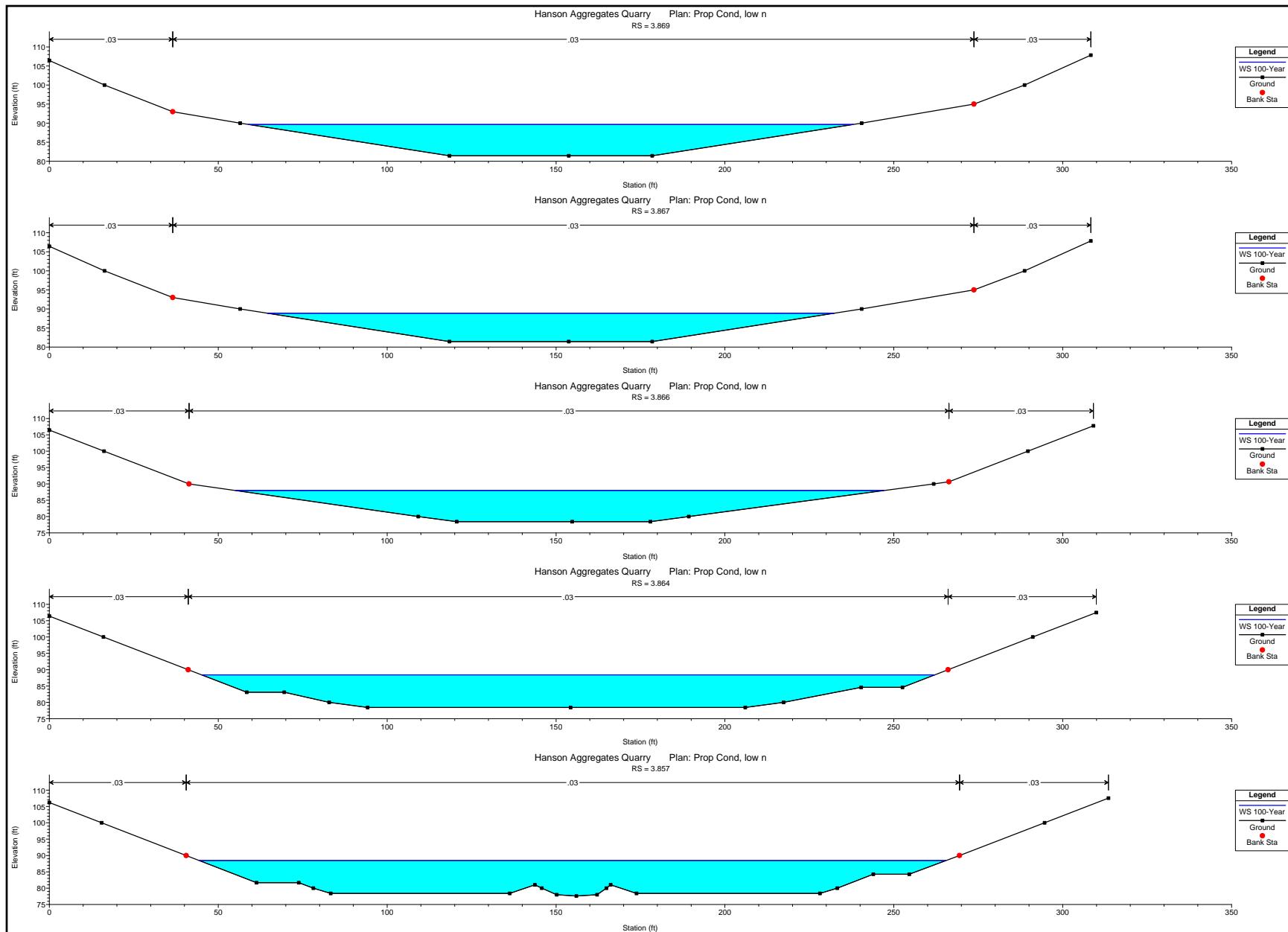


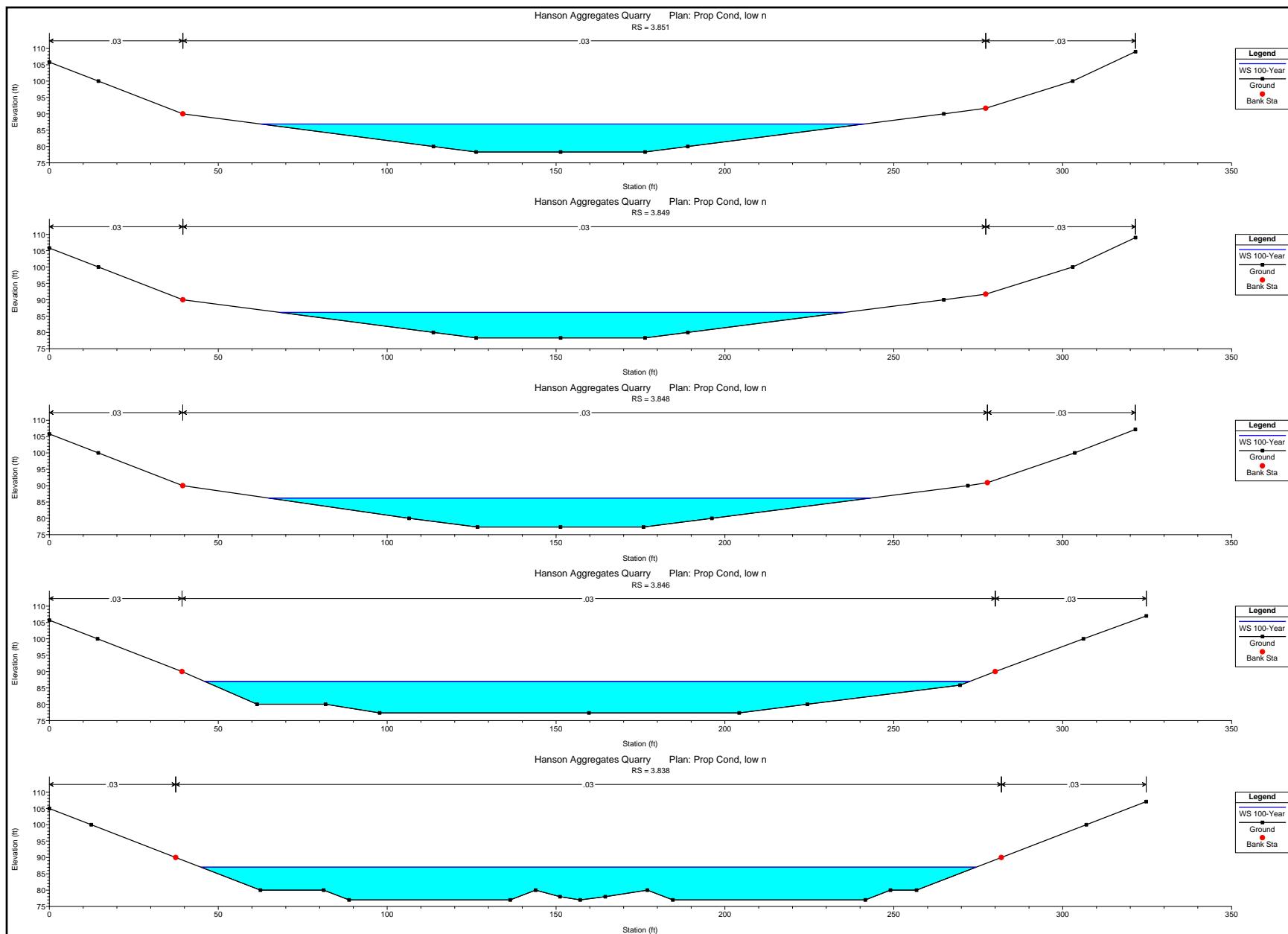


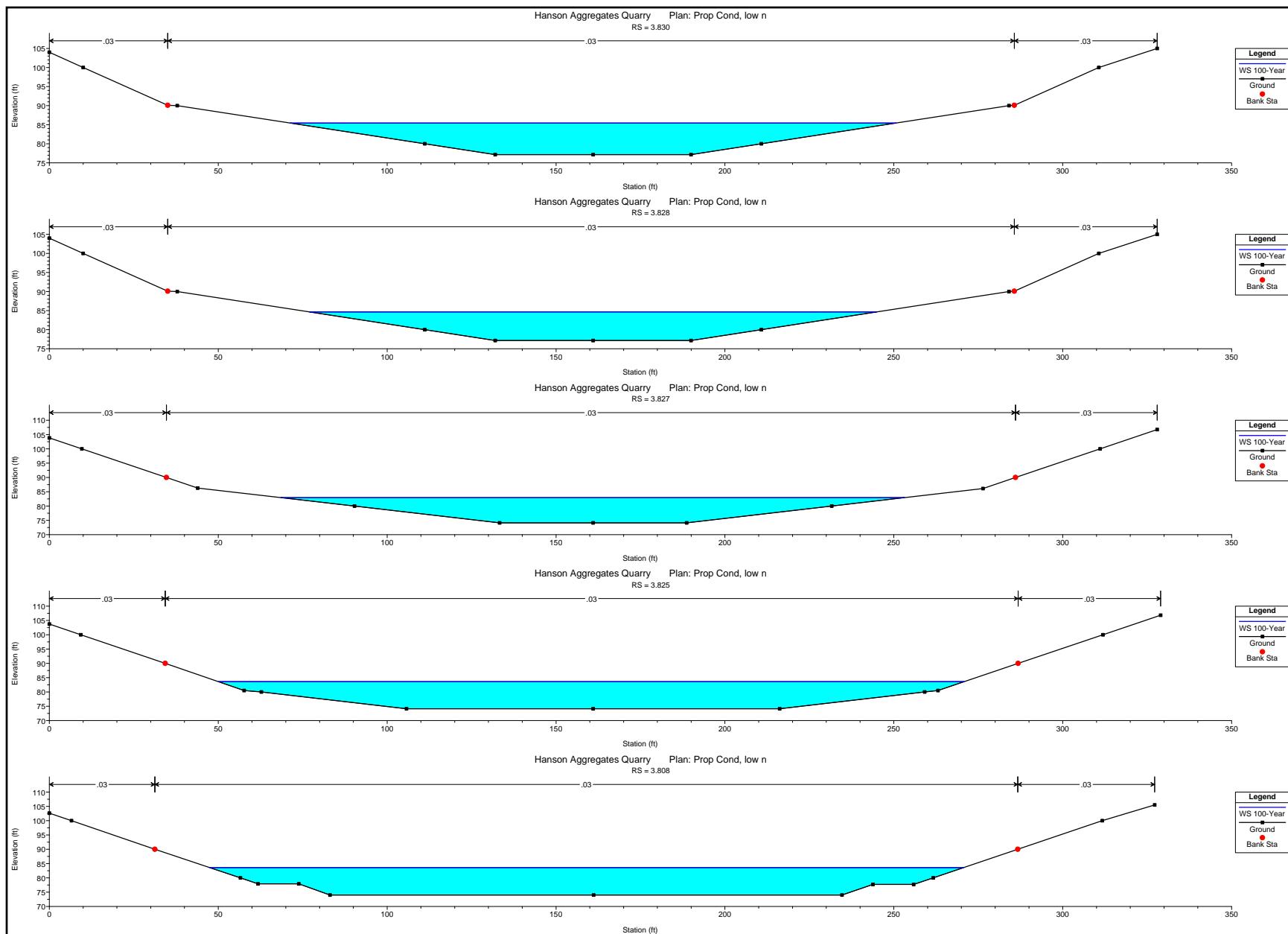


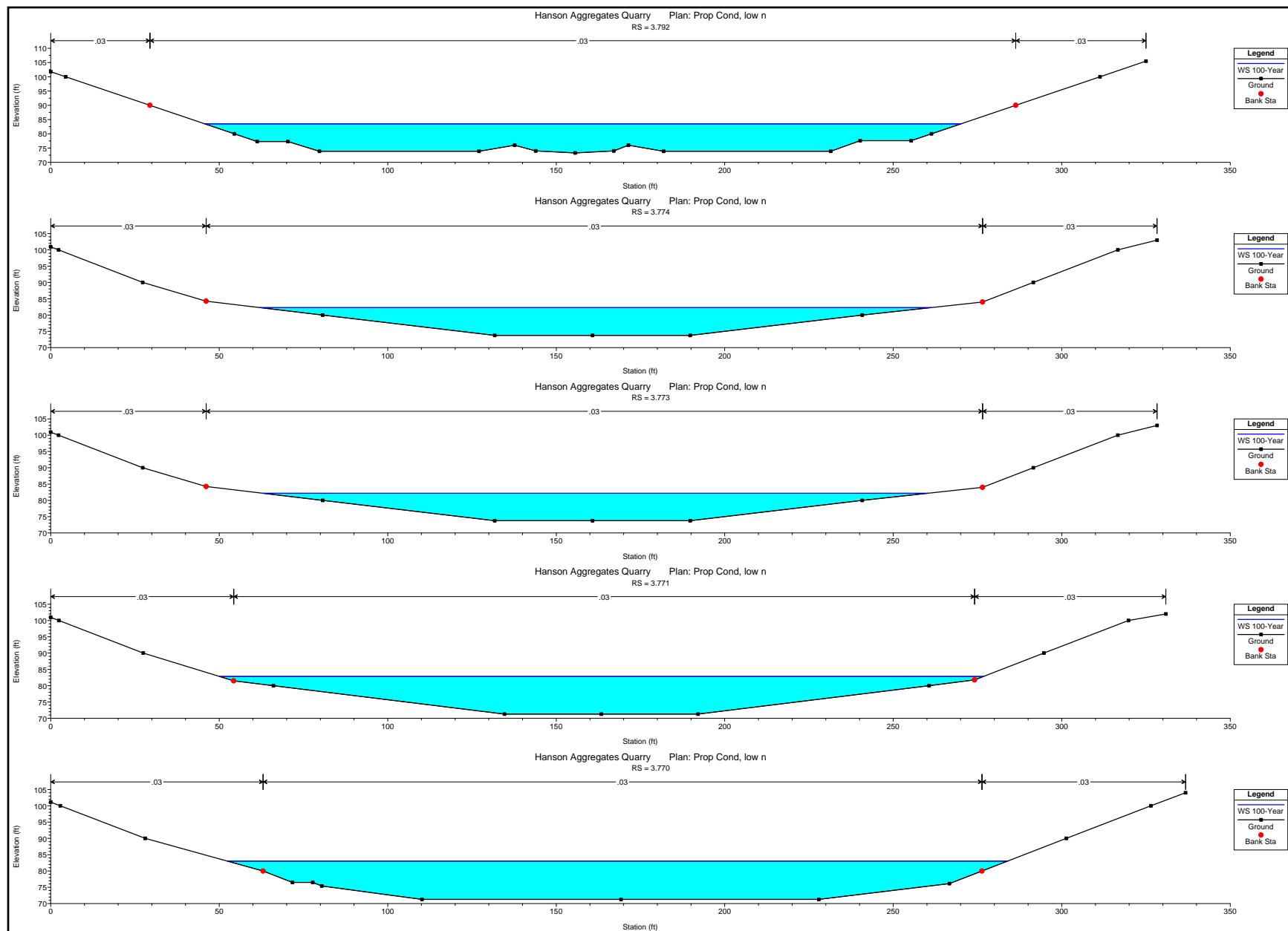


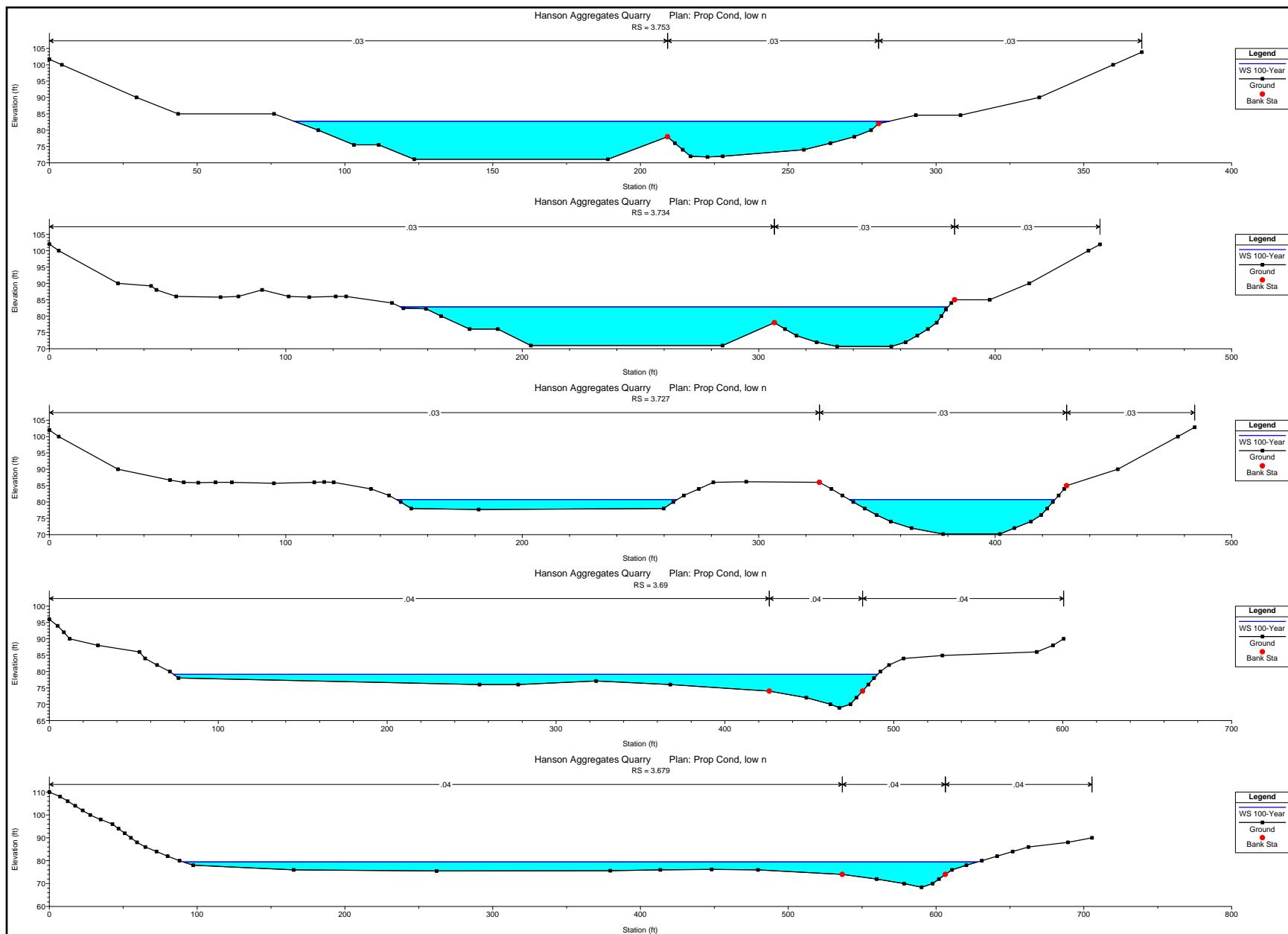


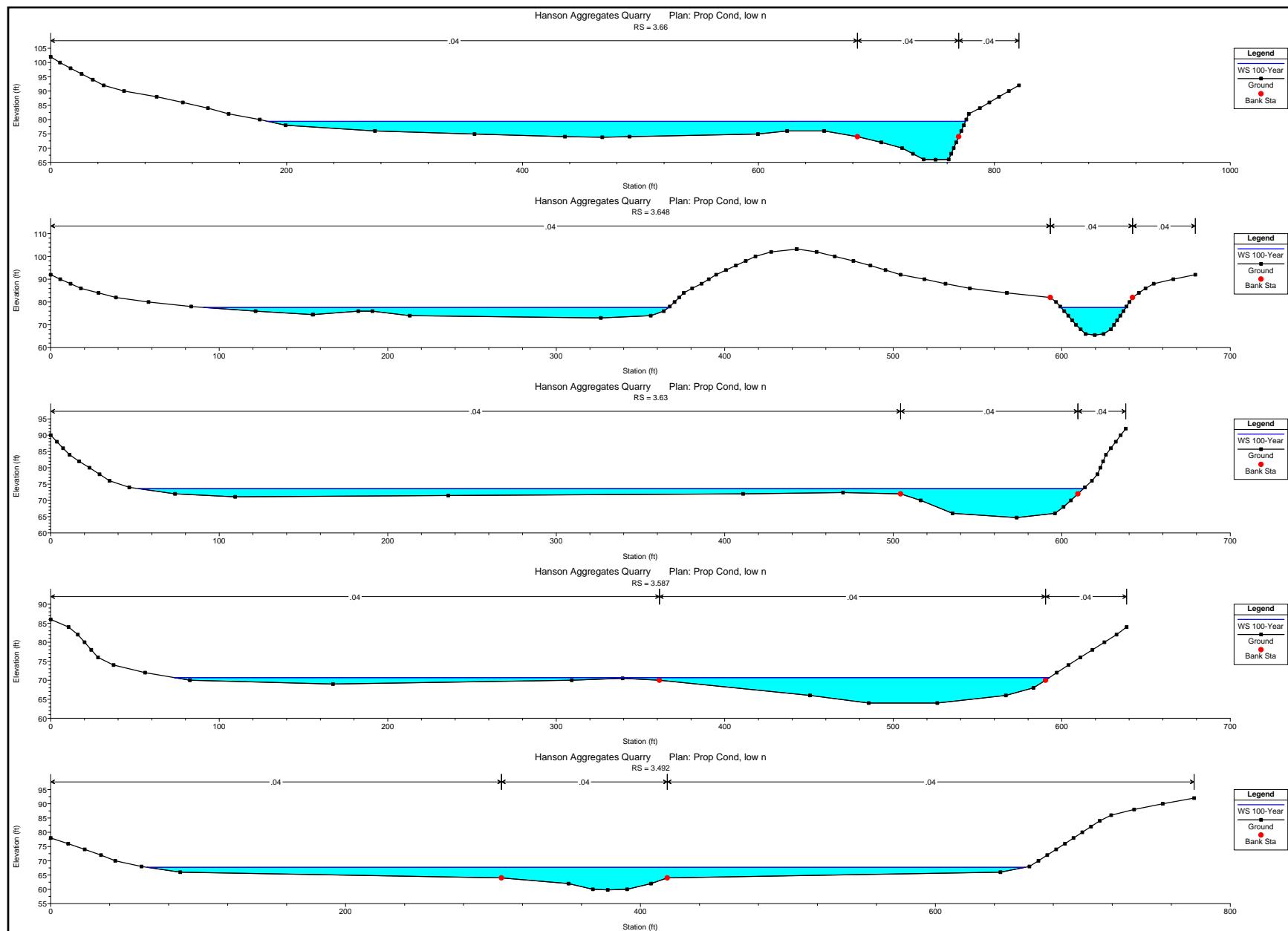












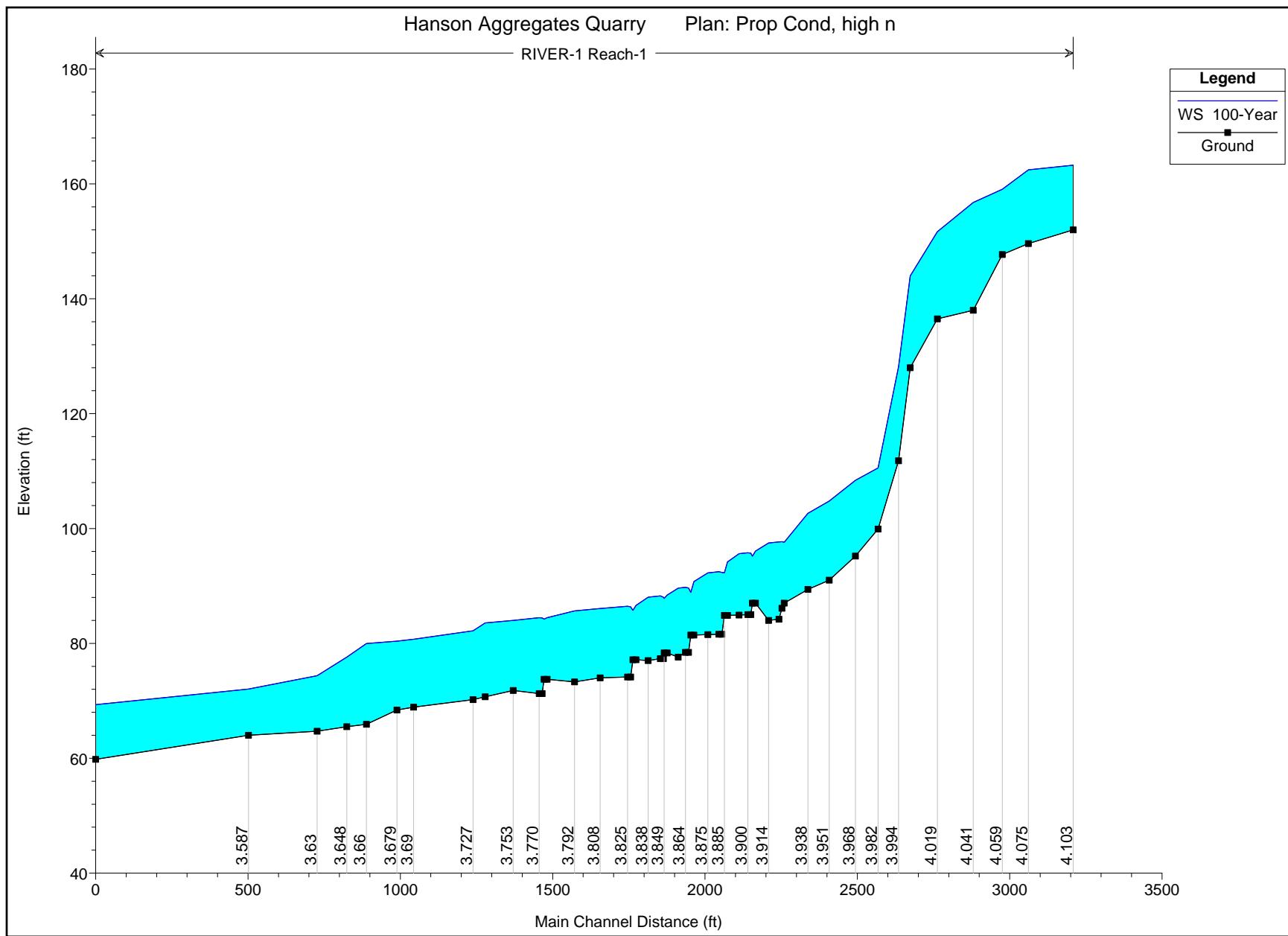
AMENDED RECLAMATION PLAN HIGH CHANNEL ROUGHNESS ANALYSIS

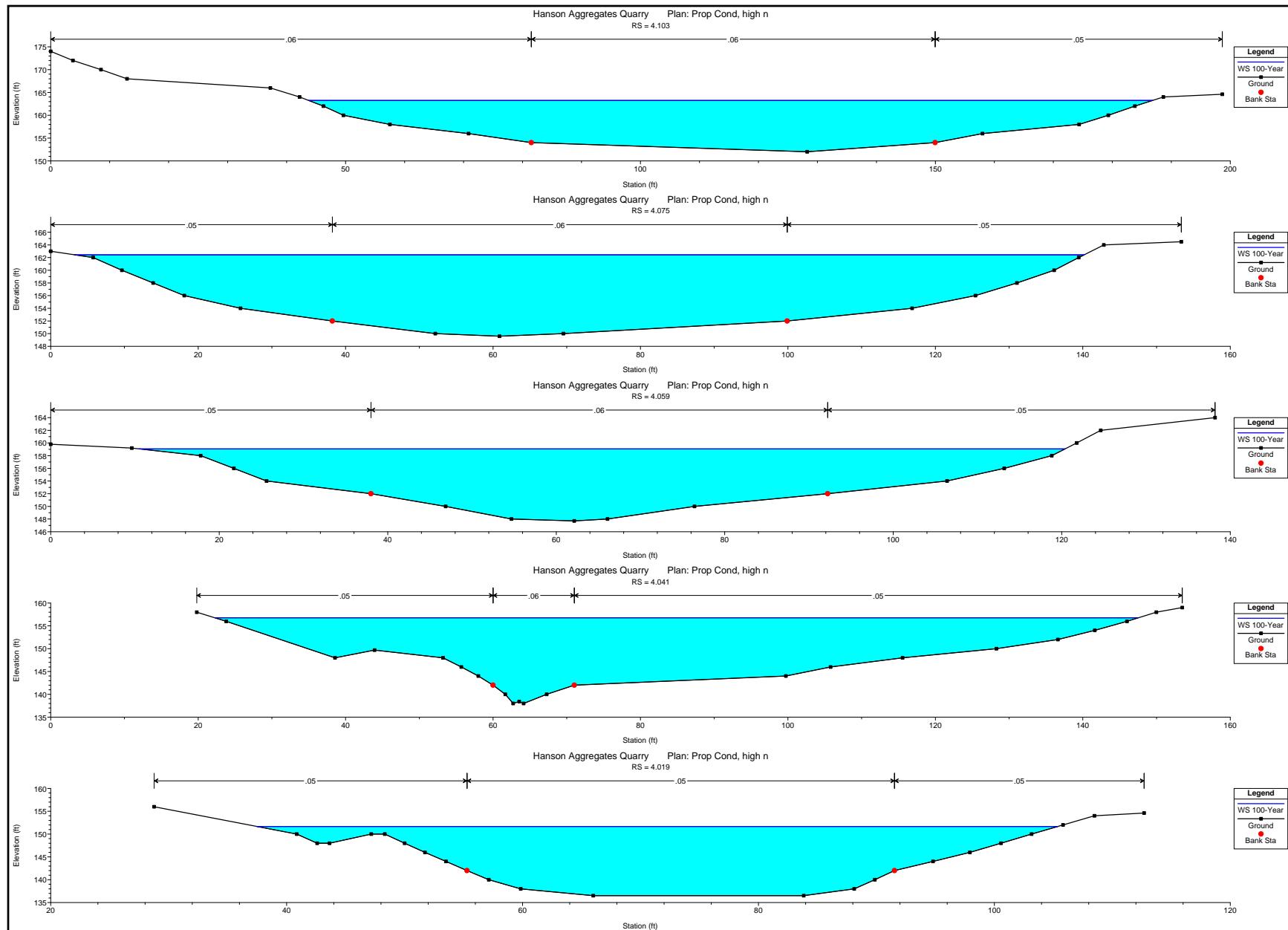
HEC-RAS Plan: PC high n River: RIVER-1 Reach: Reach-1 Profile: 100-Year

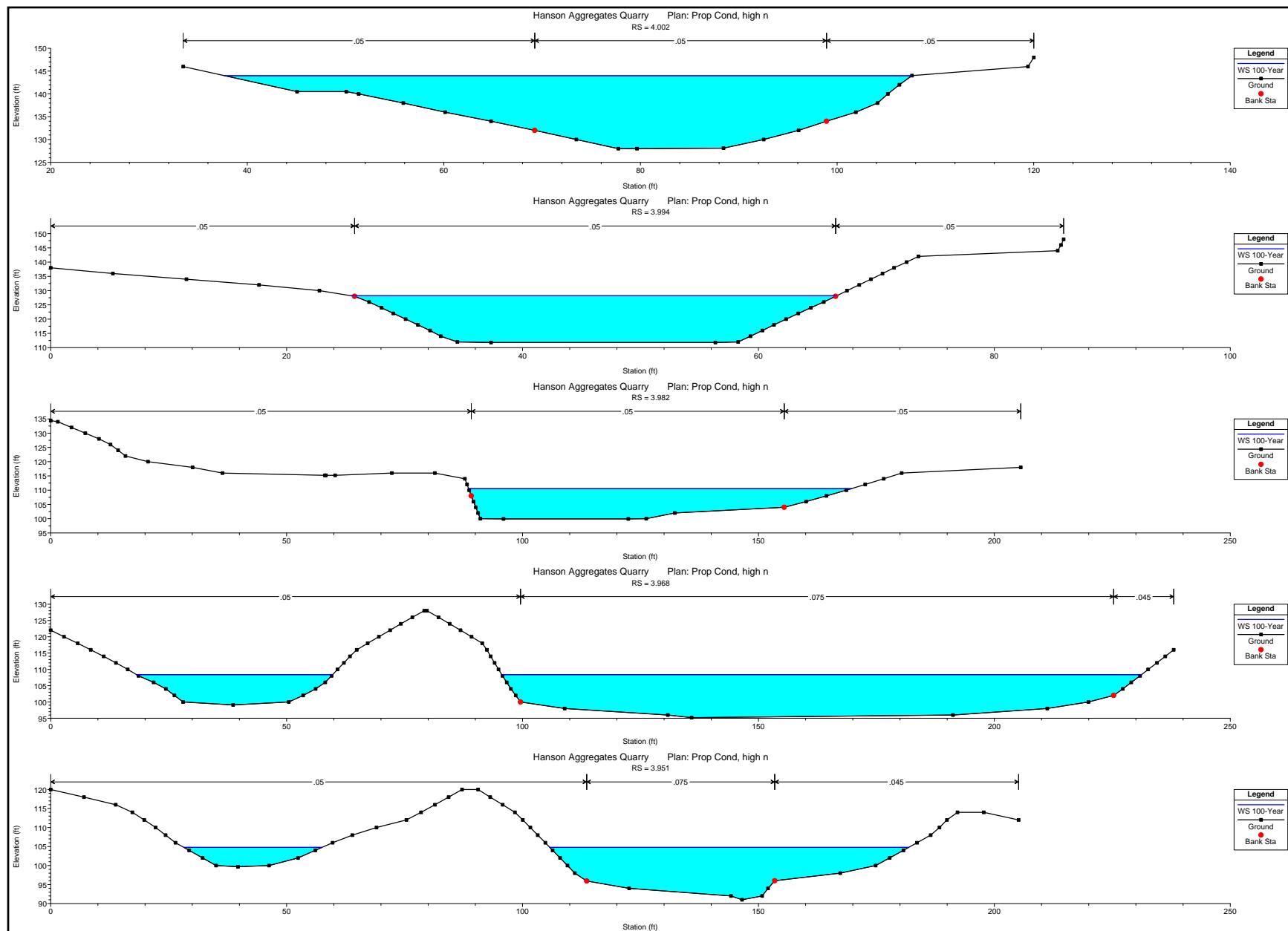
Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	3.492	100-Year	10800.00	59.80	69.33	67.01	69.57	0.004201	4.93	2885.40	618.07	0.32
Reach-1	3.587	100-Year	10800.00	64.00	72.04		72.57	0.009926	6.35	2027.92	541.54	0.47
Reach-1	3.63	100-Year	10800.00	64.70	74.37	73.59	75.01	0.011046	7.85	1975.00	570.06	0.51
Reach-1	3.648	100-Year	10800.00	65.50	77.61	77.61	79.22	0.036558	13.10	1155.11	314.46	0.82
Reach-1	3.66	100-Year	10800.00	65.90	79.97		80.17	0.002543	4.65	3280.67	598.59	0.25
Reach-1	3.679	100-Year	10800.00	68.40	80.38		80.67	0.004331	5.61	2709.64	546.36	0.33
Reach-1	3.69	100-Year	10800.00	68.90	80.71		81.24	0.008009	7.61	2032.67	425.23	0.44
Reach-1	3.727	100-Year	10800.00	70.20	82.19		83.42	0.026542	9.81	1294.23	218.08	0.59
Reach-1	3.734	100-Year	10800.00	70.70	83.55		83.89	0.004920	4.73	2308.50	234.73	0.26
Reach-1	3.753	100-Year	10800.00	71.80	83.99		84.44	0.006339	5.13	2020.29	211.18	0.29
Reach-1	3.770	100-Year	10800.00	71.26	84.48		84.77	0.003197	4.30	2553.88	240.22	0.22
Reach-1	3.771	100-Year	10800.00	71.26	84.43		84.85	0.006375	5.24	2076.45	235.73	0.30
Reach-1	3.773	100-Year	10800.00	73.76	84.24		85.03	0.018963	7.15	1511.15	230.83	0.49
Reach-1	3.774	100-Year	10800.00	73.76	84.47		85.21	0.016843	6.90	1566.49	232.28	0.47
Reach-1	3.792	100-Year	10800.00	73.30	85.65		86.00	0.004889	4.68	2305.71	235.15	0.26
Reach-1	3.808	100-Year	10800.00	74.00	86.07		86.38	0.004342	4.52	2387.00	235.63	0.25
Reach-1	3.825	100-Year	10800.00	74.14	86.46		86.80	0.004771	4.67	2312.03	234.95	0.26
Reach-1	3.827	100-Year	10800.00	74.14	86.37		86.94	0.011365	6.09	1772.37	233.22	0.39
Reach-1	3.828	100-Year	10800.00	77.16	85.75		87.43	0.048989	10.39	1039.47	183.96	0.77
Reach-1	3.830	100-Year	10800.00	77.16	86.62		87.87	0.032787	8.97	1204.39	196.66	0.64
Reach-1	3.838	100-Year	10800.00	77.00	88.04		88.44	0.006291	5.05	2136.66	234.60	0.30
Reach-1	3.846	100-Year	10800.00	77.33	88.28		88.73	0.007529	5.38	2007.95	232.65	0.32
Reach-1	3.848	100-Year	10800.00	77.33	88.04		89.01	0.022649	7.90	1367.11	204.42	0.54
Reach-1	3.849	100-Year	10800.00	78.33	87.84		89.19	0.036651	9.34	1155.76	192.87	0.67
Reach-1	3.851	100-Year	10800.00	78.33	88.42		89.54	0.028402	8.51	1269.84	201.54	0.60
Reach-1	3.857	100-Year	10800.00	77.60	89.63		90.04	0.006391	5.14	2102.34	227.02	0.30
Reach-1	3.864	100-Year	10800.00	78.43	89.76		90.21	0.007097	5.36	2013.67	223.76	0.32
Reach-1	3.866	100-Year	10800.00	78.43	89.64		90.41	0.016634	7.05	1531.37	215.34	0.47
Reach-1	3.867	100-Year	10800.00	81.45	88.89	88.89	91.41	0.085742	12.75	847.00	167.82	1.00
Reach-1	3.869	100-Year	10800.00	81.45	90.76		92.04	0.033903	9.11	1186.02	194.04	0.65
Reach-1	3.875	100-Year	10800.00	81.53	92.27		92.70	0.006396	5.28	2053.95	225.72	0.30
Reach-1	3.882	100-Year	10800.00	81.59	92.48		92.98	0.008249	5.71	1898.73	221.52	0.34
Reach-1	3.884	100-Year	10800.00	81.59	92.35		93.21	0.019470	7.42	1454.74	213.23	0.50
Reach-1	3.885	100-Year	10800.00	84.87	92.30	92.30	94.83	0.085923	12.75	847.15	168.16	1.00
Reach-1	3.887	100-Year	10800.00	84.87	94.18		95.46	0.034009	9.08	1188.87	195.69	0.65
Reach-1	3.894	100-Year	10800.00	84.94	95.62		96.02	0.006409	5.12	2108.64	231.93	0.30
Reach-1	3.900	100-Year	10800.00	85.01	95.79		96.24	0.007379	5.39	2004.42	227.95	0.32
Reach-1	3.902	100-Year	10800.00	85.01	95.69		96.43	0.015789	6.87	1573.20	223.52	0.45

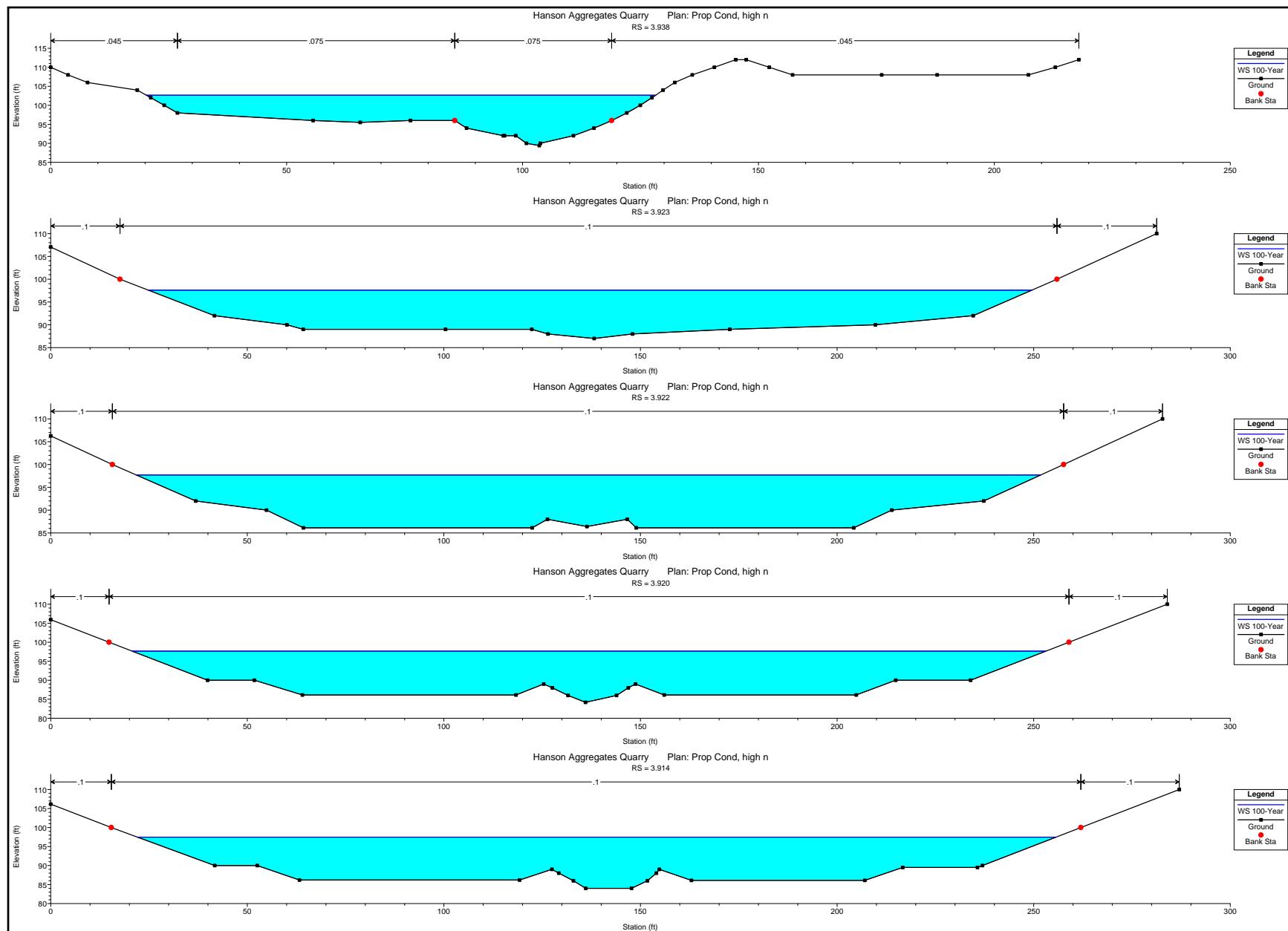
HEC-RAS Plan: PC high n River: RIVER-1 Reach: Reach-1 Profile: 100-Year (Continued)

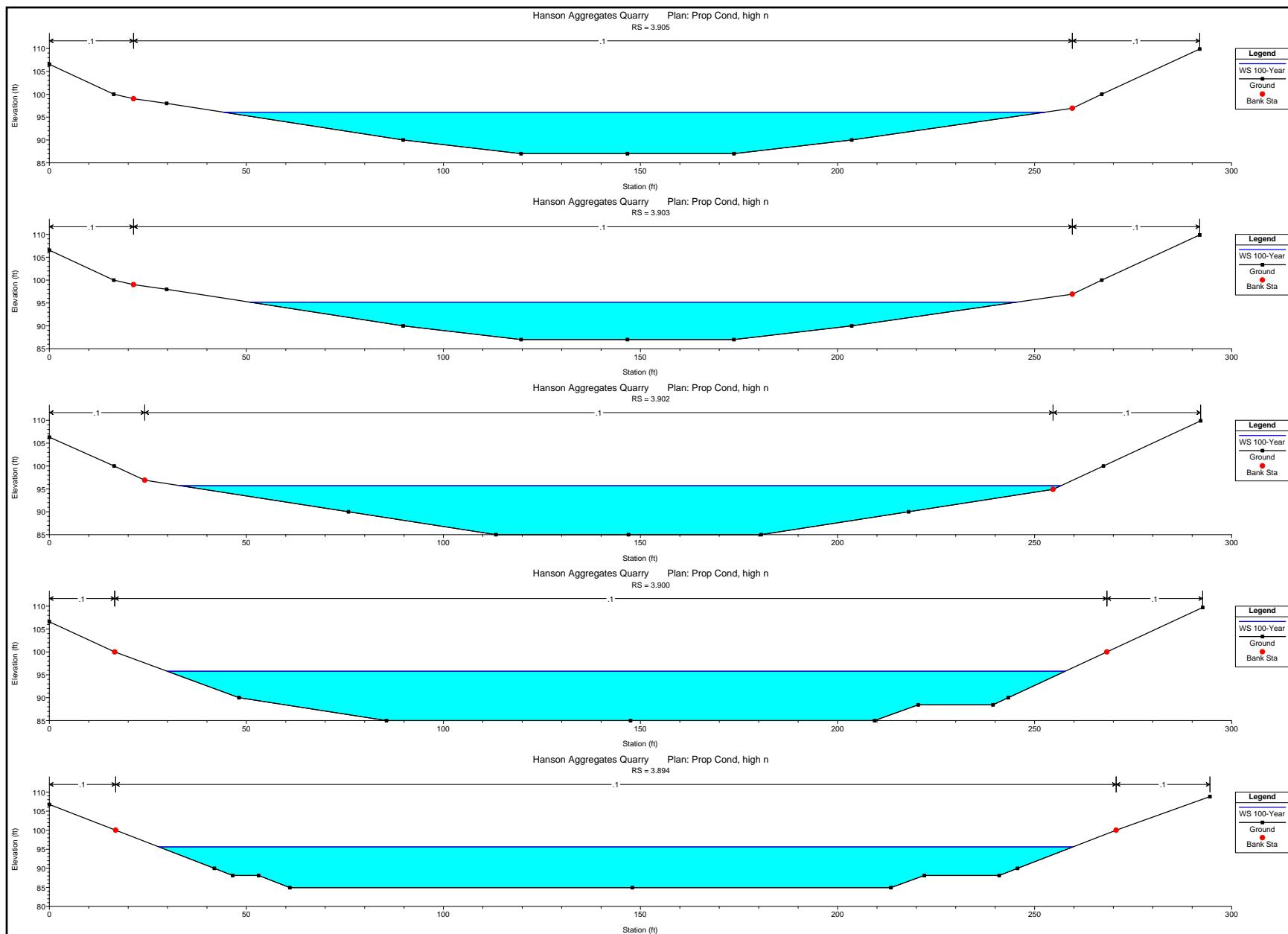
Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	3.903	100-Year	10800.00	87.01	95.19		96.83	0.050780	10.27	1051.16	194.60	0.78
Reach-1	3.905	100-Year	10800.00	87.01	96.08		97.28	0.032905	8.77	1230.84	208.48	0.64
Reach-1	3.914	100-Year	10800.00	84.00	97.47		97.85	0.005689	4.89	2206.63	233.62	0.28
Reach-1	3.920	100-Year	10800.00	84.20	97.67		98.04	0.005682	4.91	2200.55	232.43	0.28
Reach-1	3.922	100-Year	10800.00	86.12	97.71		98.11	0.006066	5.04	2140.83	230.05	0.29
Reach-1	3.923	100-Year	10800.00	87.00	97.60		98.24	0.012766	6.39	1688.92	224.73	0.41
Reach-1	3.938	100-Year	10800.00	89.40	102.64	102.64	106.01	0.035712	16.49	753.87	107.88	0.91
Reach-1	3.951	100-Year	10800.00	91.00	104.78	104.47	108.04	0.023261	14.74	767.09	105.37	0.77
Reach-1	3.968	100-Year	10800.00	95.20	108.39		108.97	0.003755	6.19	1776.47	177.23	0.32
Reach-1	3.982	100-Year	10800.00	99.90	110.55	110.55	114.80	0.018461	16.79	667.64	81.15	0.97
Reach-1	3.994	100-Year	10800.00	111.80	128.19	128.19	134.66	0.025955	20.42	529.05	41.17	1.00
Reach-1	4.002	100-Year	10800.00	128.00	143.99	143.99	149.09	0.014008	19.76	658.68	69.90	0.92
Reach-1	4.019	100-Year	10800.00	136.50	151.68	151.68	156.80	0.013457	18.93	648.36	67.91	0.88
Reach-1	4.041	100-Year	10800.00	138.00	156.76	153.07	158.09	0.005242	9.84	1187.05	125.22	0.42
Reach-1	4.059	100-Year	10800.00	147.70	159.07	159.07	162.64	0.021998	16.20	739.15	109.91	0.93
Reach-1	4.075	100-Year	10800.00	149.60	162.44		163.70	0.005696	9.65	1221.90	136.99	0.50
Reach-1	4.103	100-Year	10800.00	152.00	163.26		164.81	0.008583	10.82	1118.10	143.15	0.60

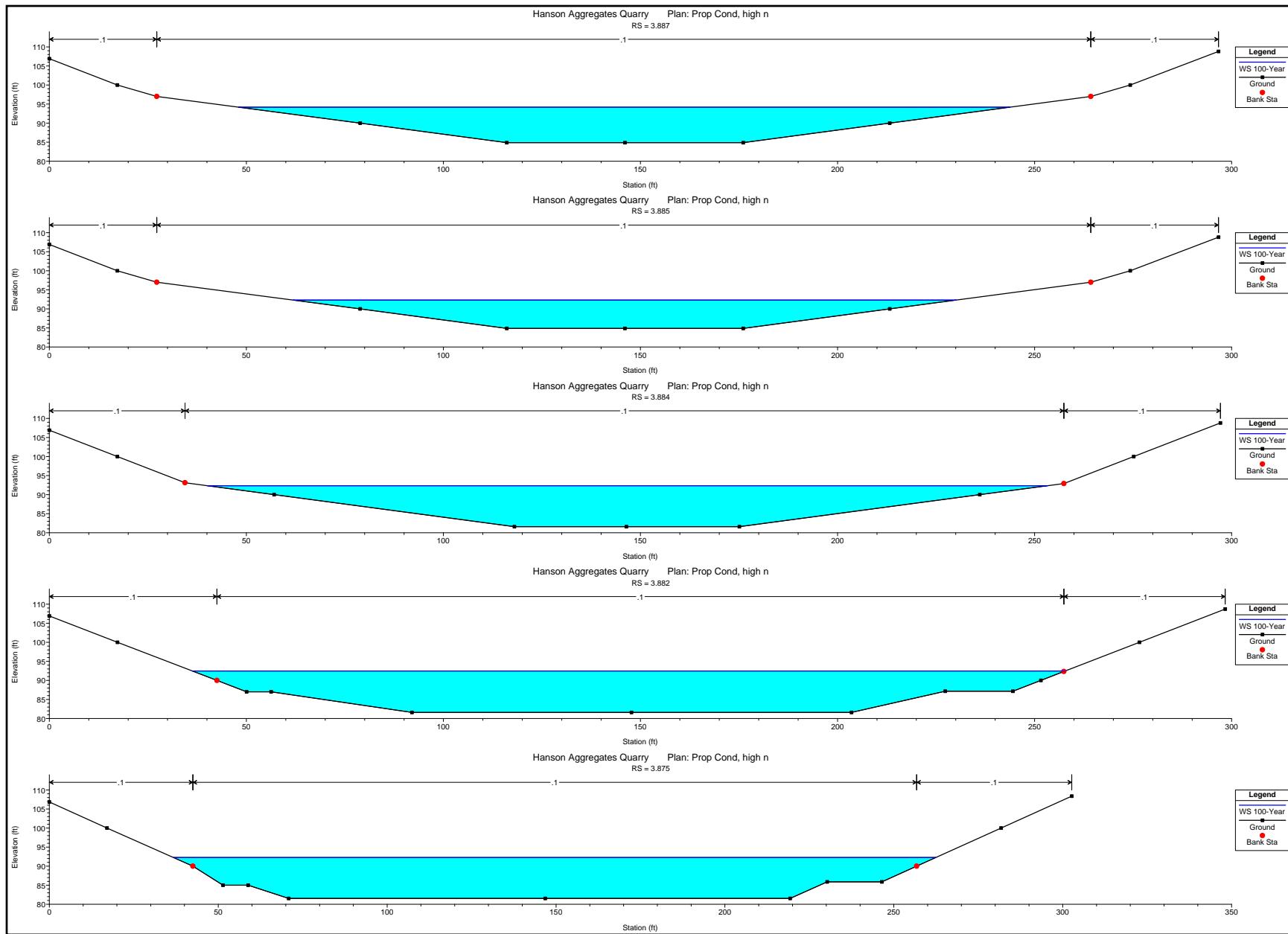


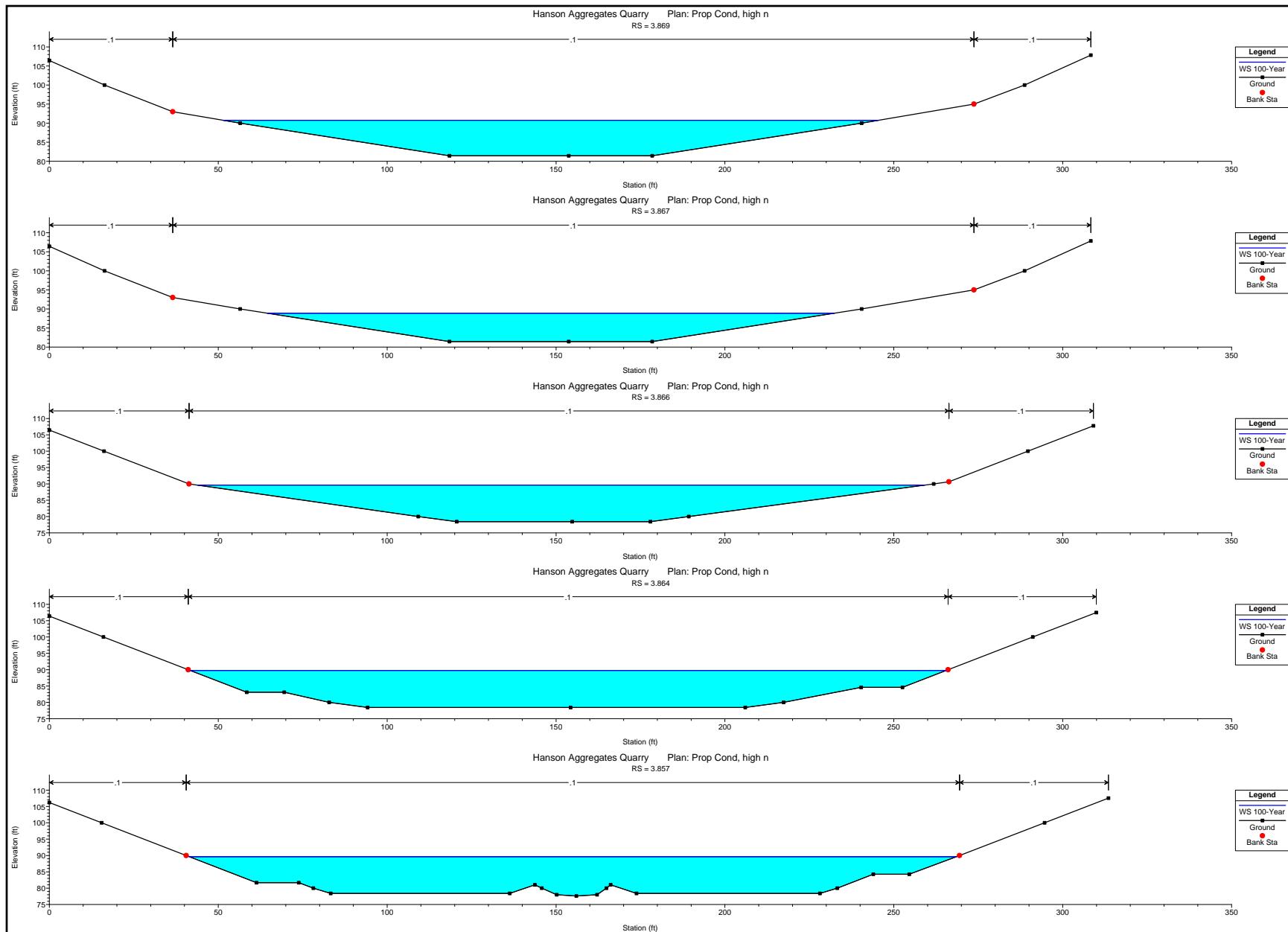


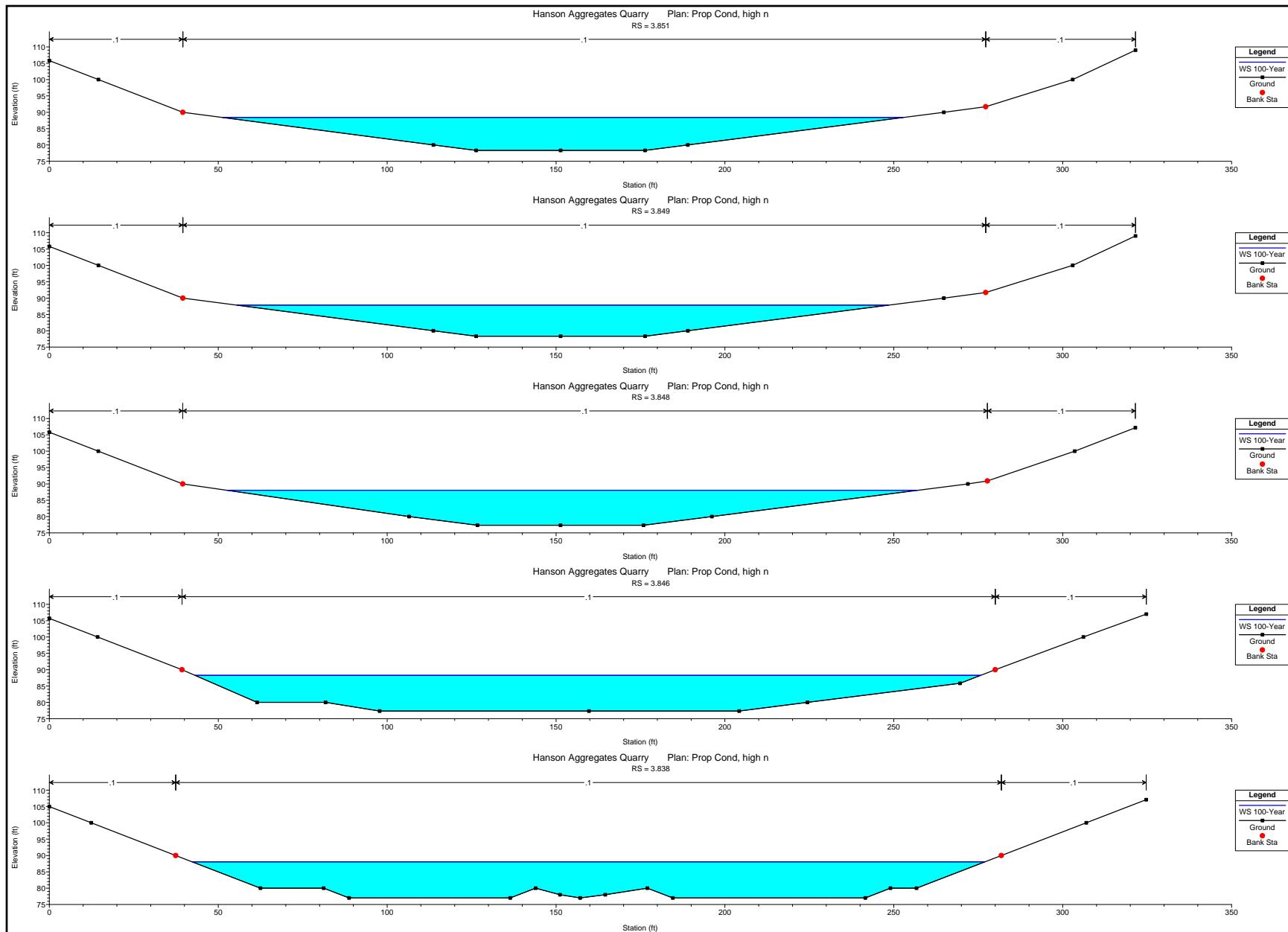


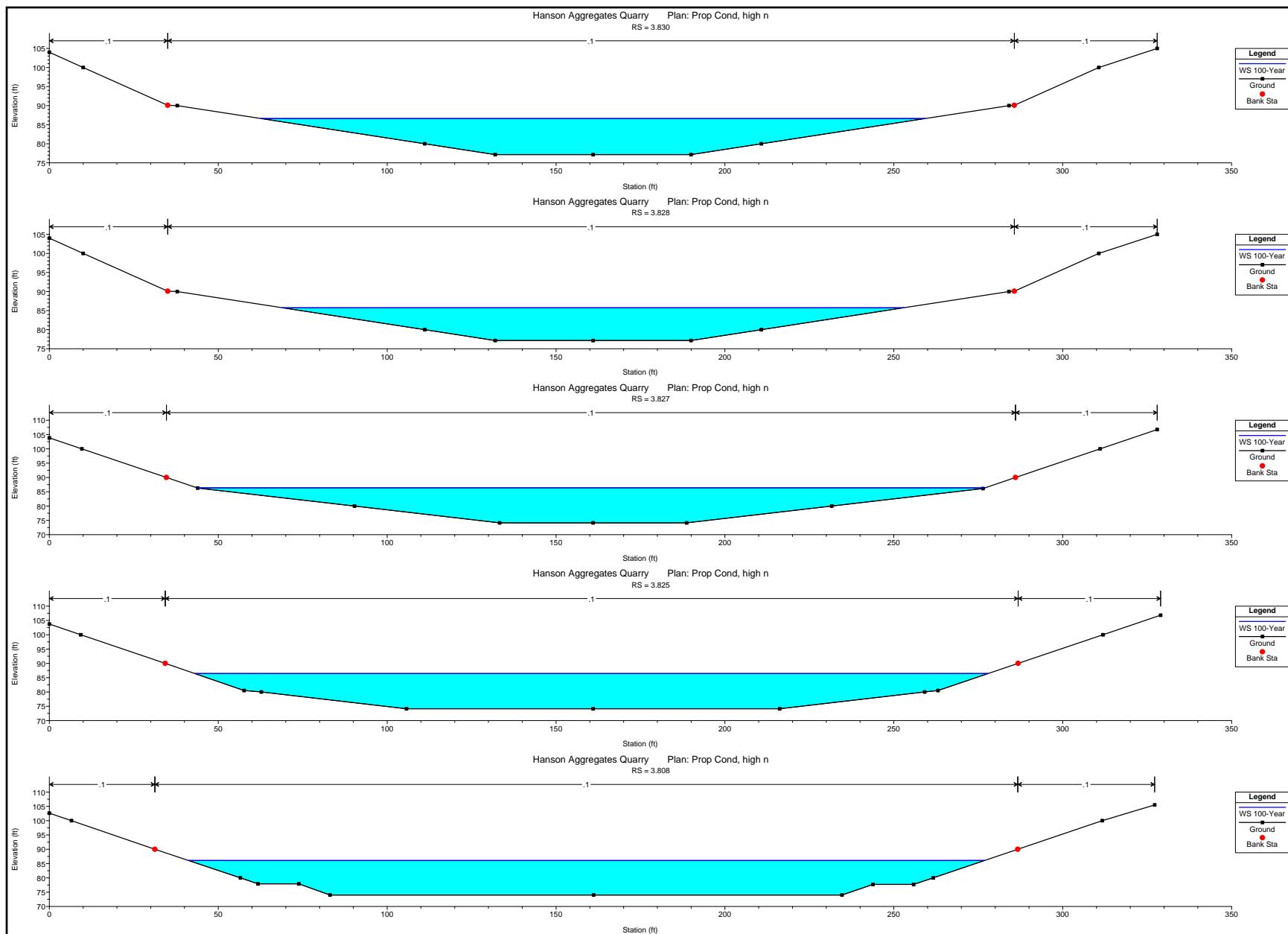


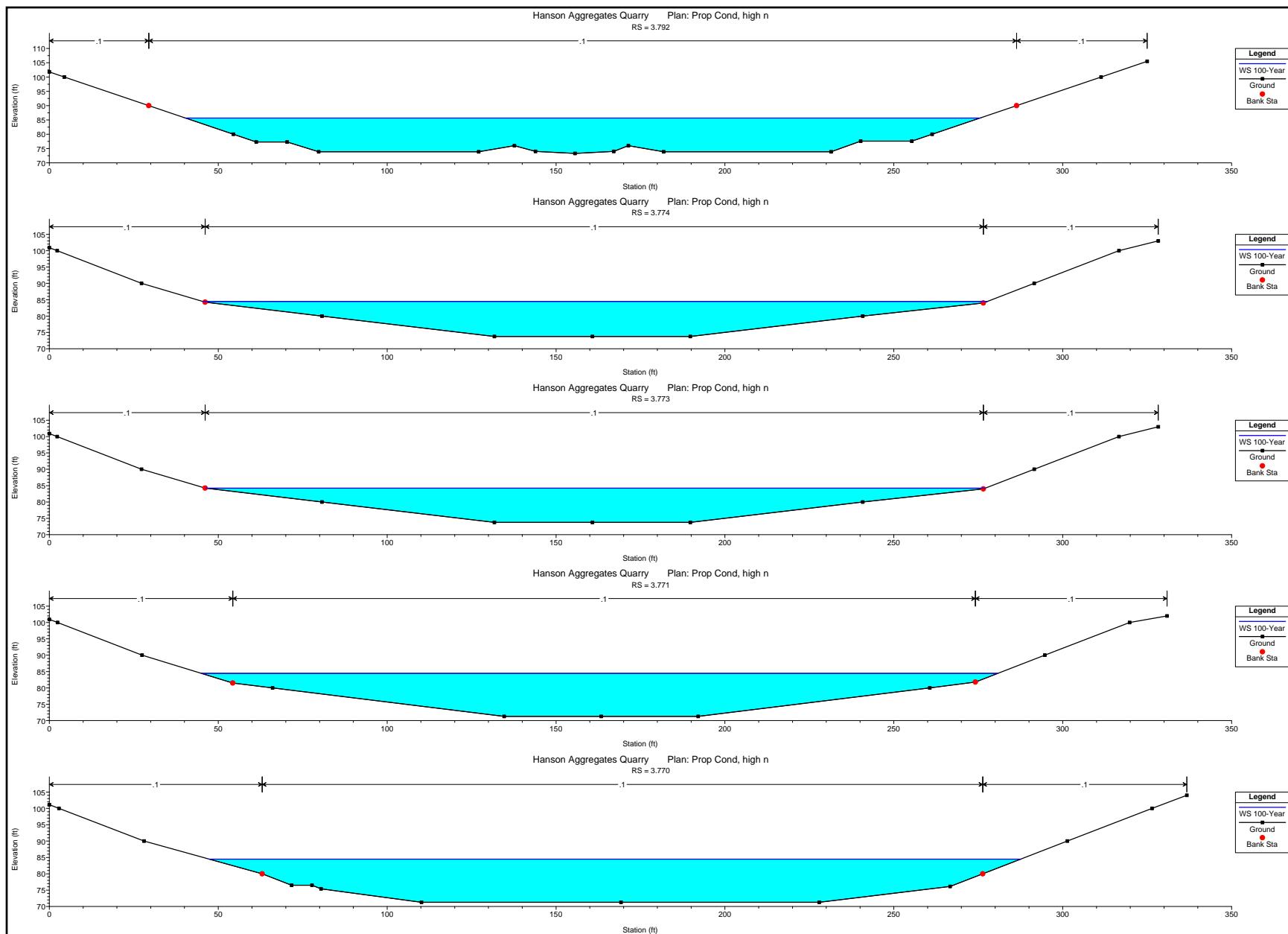


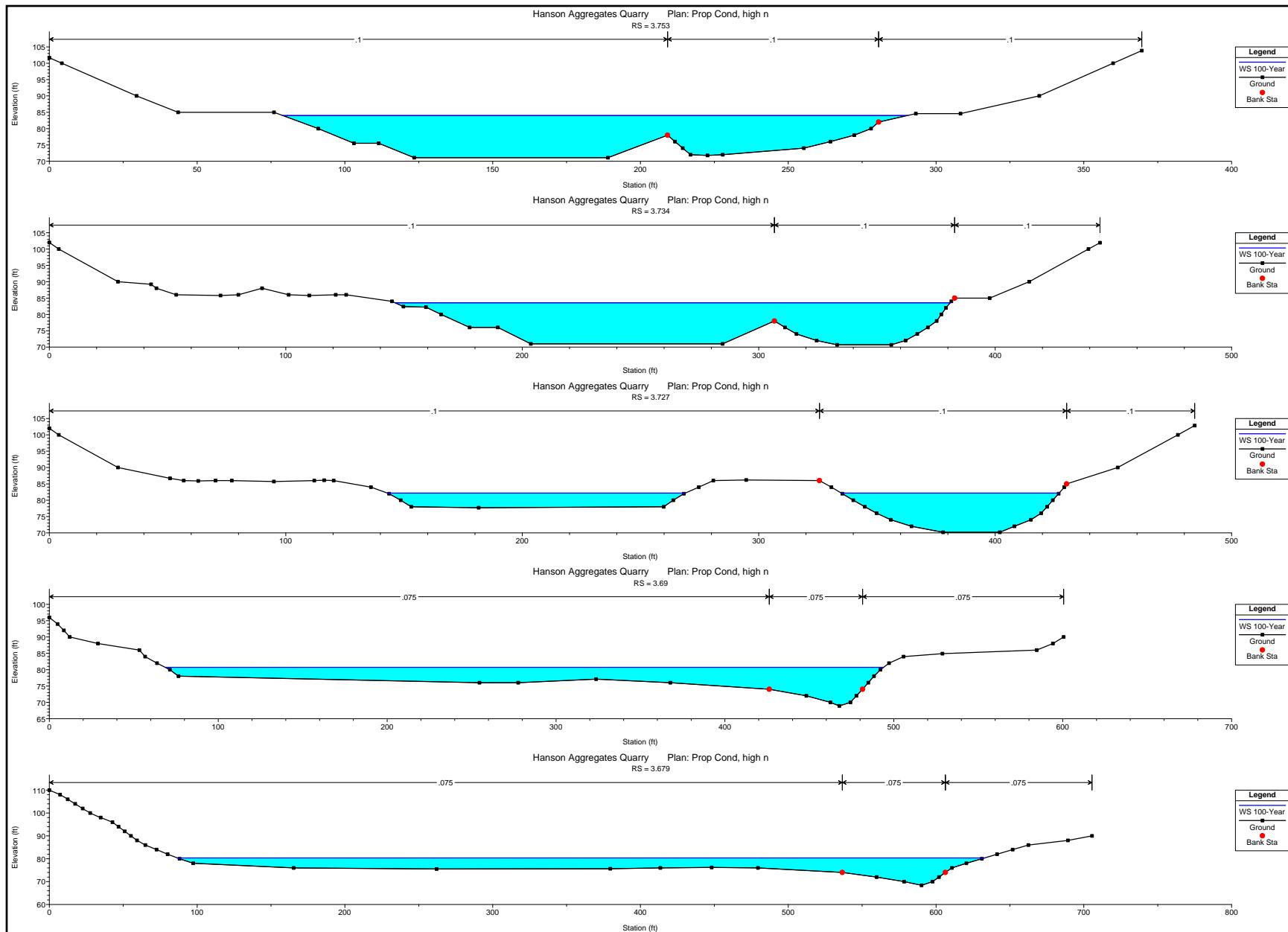


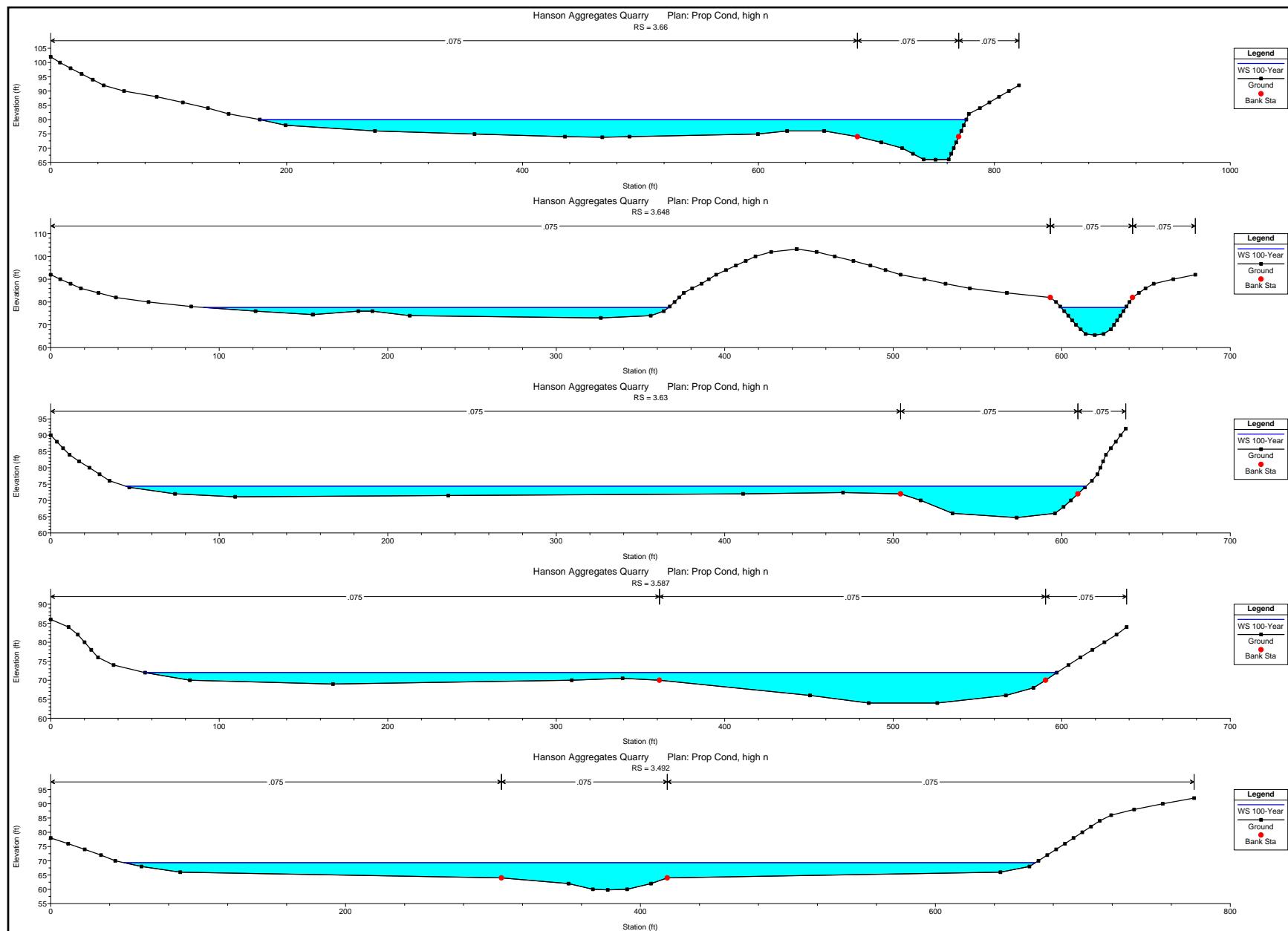












APPENDIX B

100-YEAR HEC-RAS ANALYSES

WITH BRIDGE

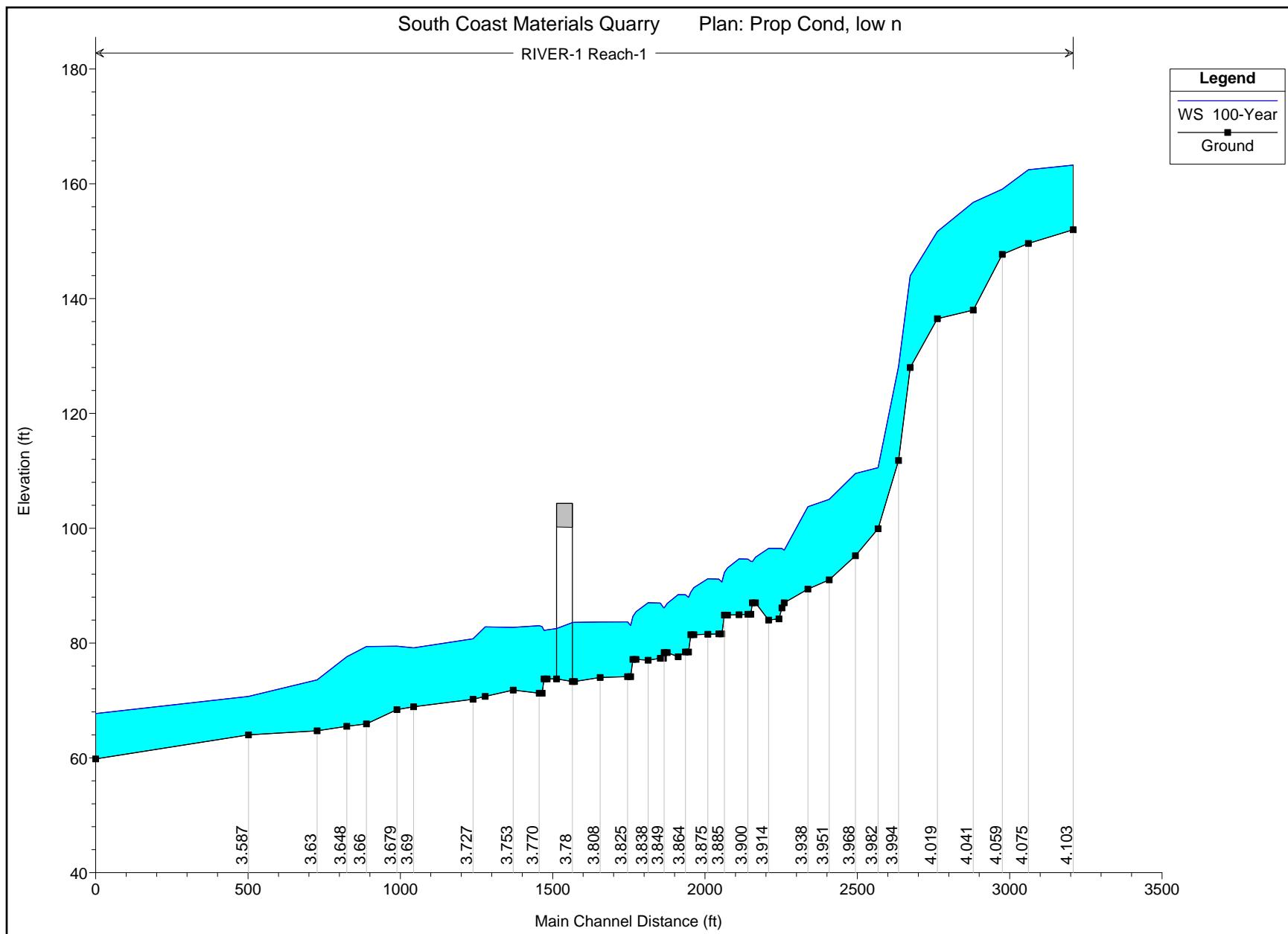
LOW CHANNEL ROUGHNESS ANALYSIS

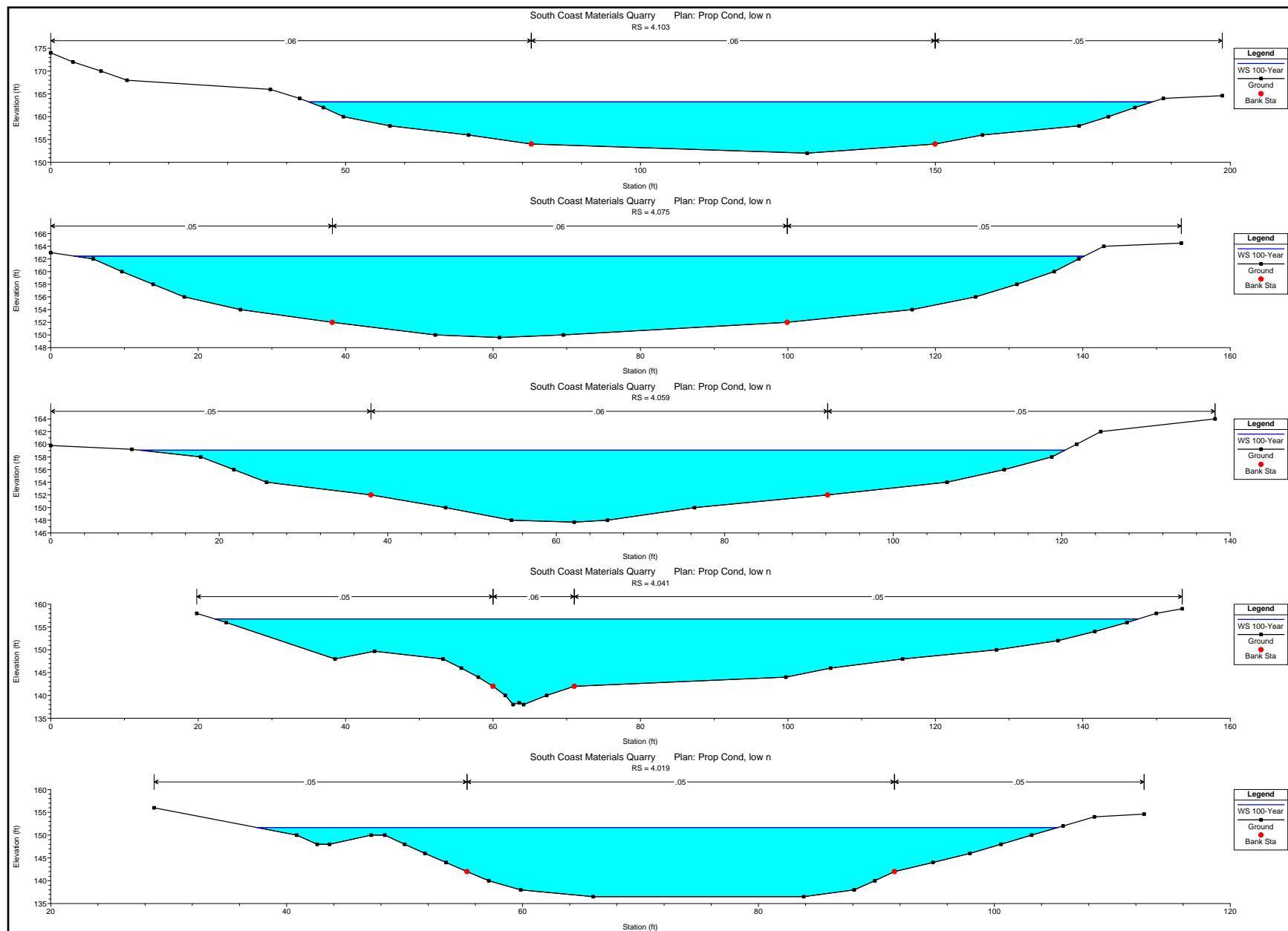
HEC-RAS Plan: PC low n River: RIVER-1 Reach: Reach-1 Profile: 100-Year

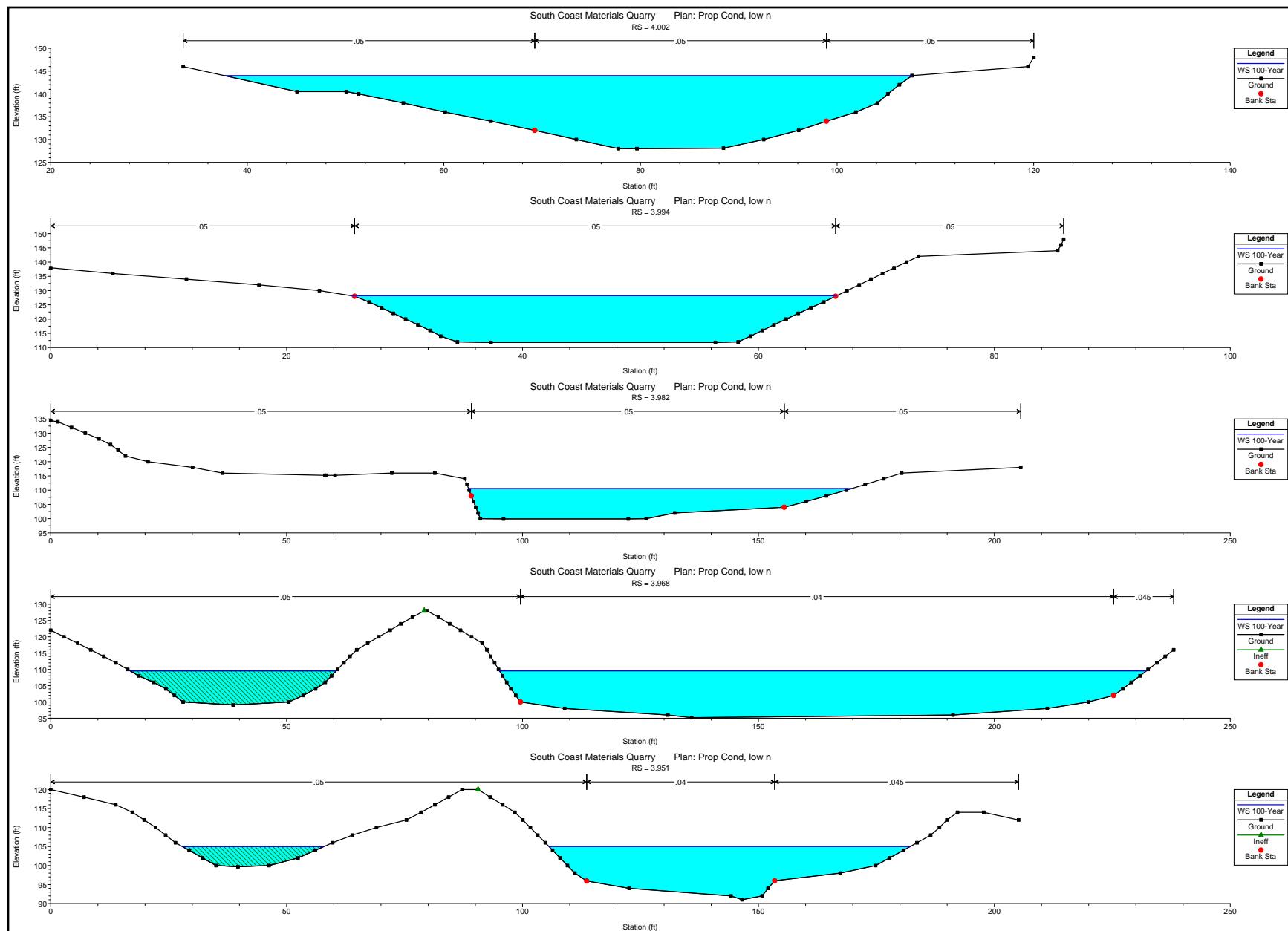
Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	3.492	100-Year	10800.00	59.80	67.71	67.01	68.33	0.004202	7.86	1901.22	595.42	0.57
Reach-1	3.587	100-Year	10800.00	64.00	70.70	70.70	71.99	0.009097	9.55	1316.24	519.39	0.80
Reach-1	3.63	100-Year	10800.00	64.70	73.59	73.59	74.76	0.006141	10.19	1536.90	560.76	0.70
Reach-1	3.648	100-Year	10800.00	65.50	77.61	77.61	79.22	0.010399	13.10	1155.11	314.46	0.82
Reach-1	3.66	100-Year	10800.00	65.90	79.39		79.65	0.001006	5.28	2934.94	591.64	0.30
Reach-1	3.679	100-Year	10800.00	68.40	79.46		79.92	0.002292	7.12	2208.87	537.48	0.44
Reach-1	3.69	100-Year	10800.00	68.90	79.16	79.12	80.49	0.007214	11.95	1379.35	416.97	0.77
Reach-1	3.727	100-Year	10800.00	70.20	80.74	80.74	82.97	0.004881	12.99	988.16	205.75	0.83
Reach-1	3.734	100-Year	10800.00	70.70	82.81		83.21	0.000564	5.12	2134.49	231.62	0.29
Reach-1	3.753	100-Year	10800.00	71.80	82.74		83.33	0.000865	5.74	1762.09	201.38	0.35
Reach-1	3.770	100-Year	10800.00	71.26	83.01		83.39	0.000454	4.94	2207.27	231.39	0.27
Reach-1	3.771	100-Year	10800.00	71.26	82.85		83.47	0.001069	6.32	1711.31	226.80	0.40
Reach-1	3.773	100-Year	10800.00	73.76	82.19		83.77	0.004357	10.07	1072.77	197.52	0.76
Reach-1	3.774	100-Year	10800.00	73.76	82.30		83.81	0.004144	9.88	1092.82	199.24	0.74
Reach-1	3.78	Bridge										
Reach-1	3.792	100-Year	10800.00	73.30	83.60	79.23	84.14	0.000889	5.89	1832.28	224.85	0.36
Reach-1	3.808	100-Year	10800.00	74.00	83.67		84.21	0.000868	5.88	1837.64	223.59	0.36
Reach-1	3.825	100-Year	10800.00	74.14	83.69		84.33	0.001143	6.43	1679.83	221.21	0.41
Reach-1	3.827	100-Year	10800.00	74.14	83.07		84.63	0.003965	10.01	1078.64	186.29	0.73
Reach-1	3.828	100-Year	10800.00	77.16	84.64	84.64	87.18	0.007820	12.81	843.17	167.59	1.01
Reach-1	3.830	100-Year	10800.00	77.16	85.44	84.63	87.32	0.005129	10.98	983.48	179.44	0.83
Reach-1	3.838	100-Year	10800.00	77.00	87.02		87.52	0.000813	5.69	1898.90	229.45	0.35
Reach-1	3.846	100-Year	10800.00	77.33	86.97		87.59	0.001119	6.32	1707.73	226.47	0.41
Reach-1	3.848	100-Year	10800.00	77.33	86.20		87.96	0.004575	10.64	1015.06	178.14	0.79
Reach-1	3.849	100-Year	10800.00	78.33	86.11	86.11	88.65	0.007713	12.77	845.56	167.02	1.00
Reach-1	3.851	100-Year	10800.00	78.33	86.90	86.11	88.78	0.005154	11.01	980.53	178.73	0.83
Reach-1	3.857	100-Year	10800.00	77.60	88.44		88.98	0.000869	5.88	1836.86	220.98	0.36
Reach-1	3.864	100-Year	10800.00	78.43	88.41		89.02	0.001044	6.30	1715.39	216.99	0.39
Reach-1	3.866	100-Year	10800.00	78.43	87.96		89.24	0.002971	9.07	1190.24	191.82	0.64
Reach-1	3.867	100-Year	10800.00	81.45	88.88	88.88	91.41	0.007744	12.77	845.93	167.72	1.00
Reach-1	3.869	100-Year	10800.00	81.45	89.66	88.88	91.54	0.005147	11.00	981.65	179.07	0.83
Reach-1	3.875	100-Year	10800.00	81.53	91.20		91.75	0.000857	5.96	1816.26	220.35	0.36
Reach-1	3.882	100-Year	10800.00	81.59	91.13		91.84	0.001263	6.73	1605.14	214.76	0.43
Reach-1	3.884	100-Year	10800.00	81.59	90.61		92.09	0.003700	9.77	1105.05	187.91	0.71
Reach-1	3.885	100-Year	10800.00	84.87	92.30	92.30	94.83	0.007750	12.76	846.49	168.10	1.00
Reach-1	3.887	100-Year	10800.00	84.87	93.08	92.30	94.96	0.005147	10.99	982.82	179.60	0.83
Reach-1	3.894	100-Year	10800.00	84.94	94.65		95.16	0.000811	5.72	1886.65	227.09	0.35
Reach-1	3.900	100-Year	10800.00	85.01	94.61		95.21	0.001019	6.20	1741.21	221.33	0.39

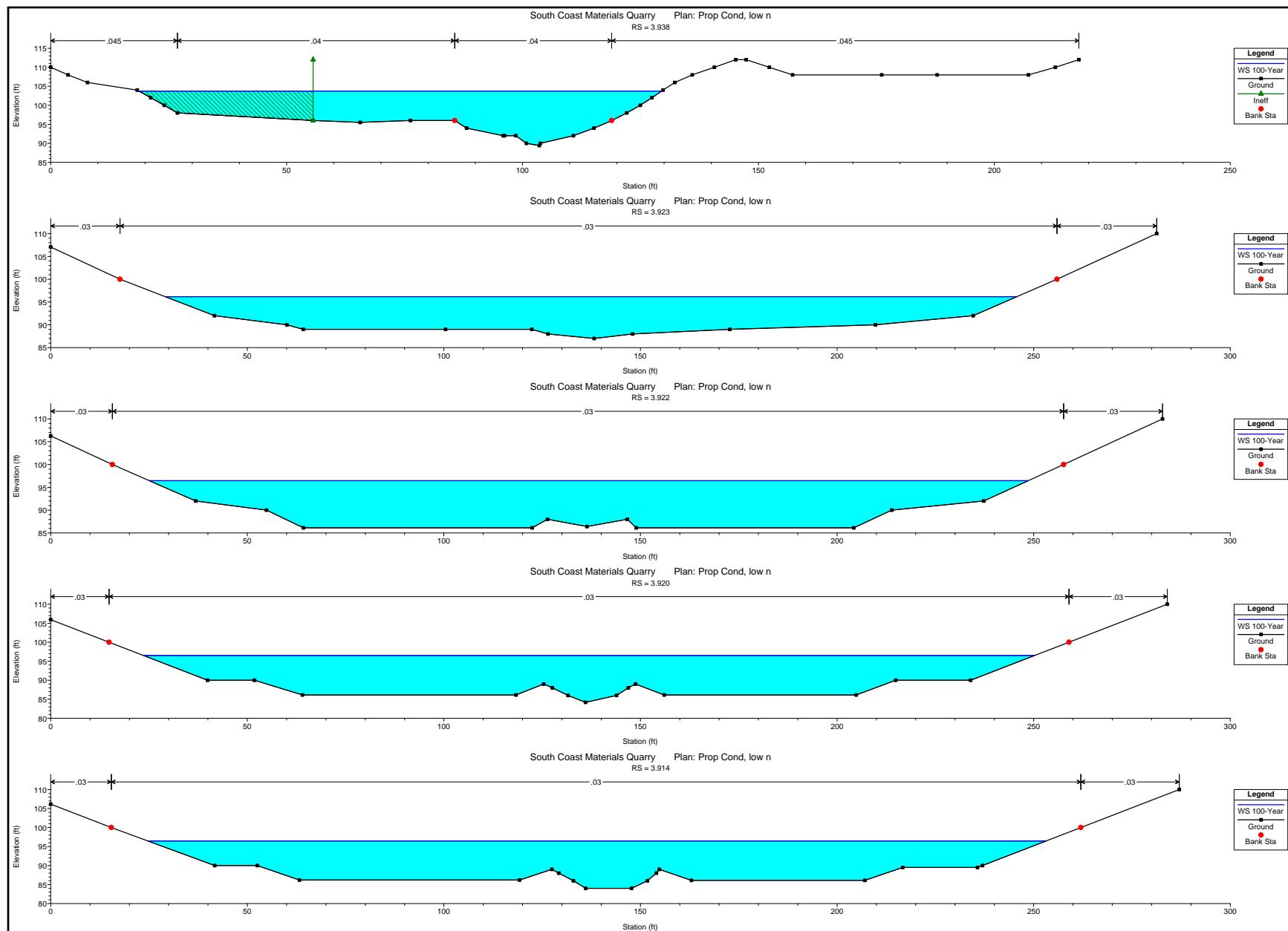
HEC-RAS Plan: PC low n River: RIVER-1 Reach: Reach-1 Profile: 100-Year (Continued)

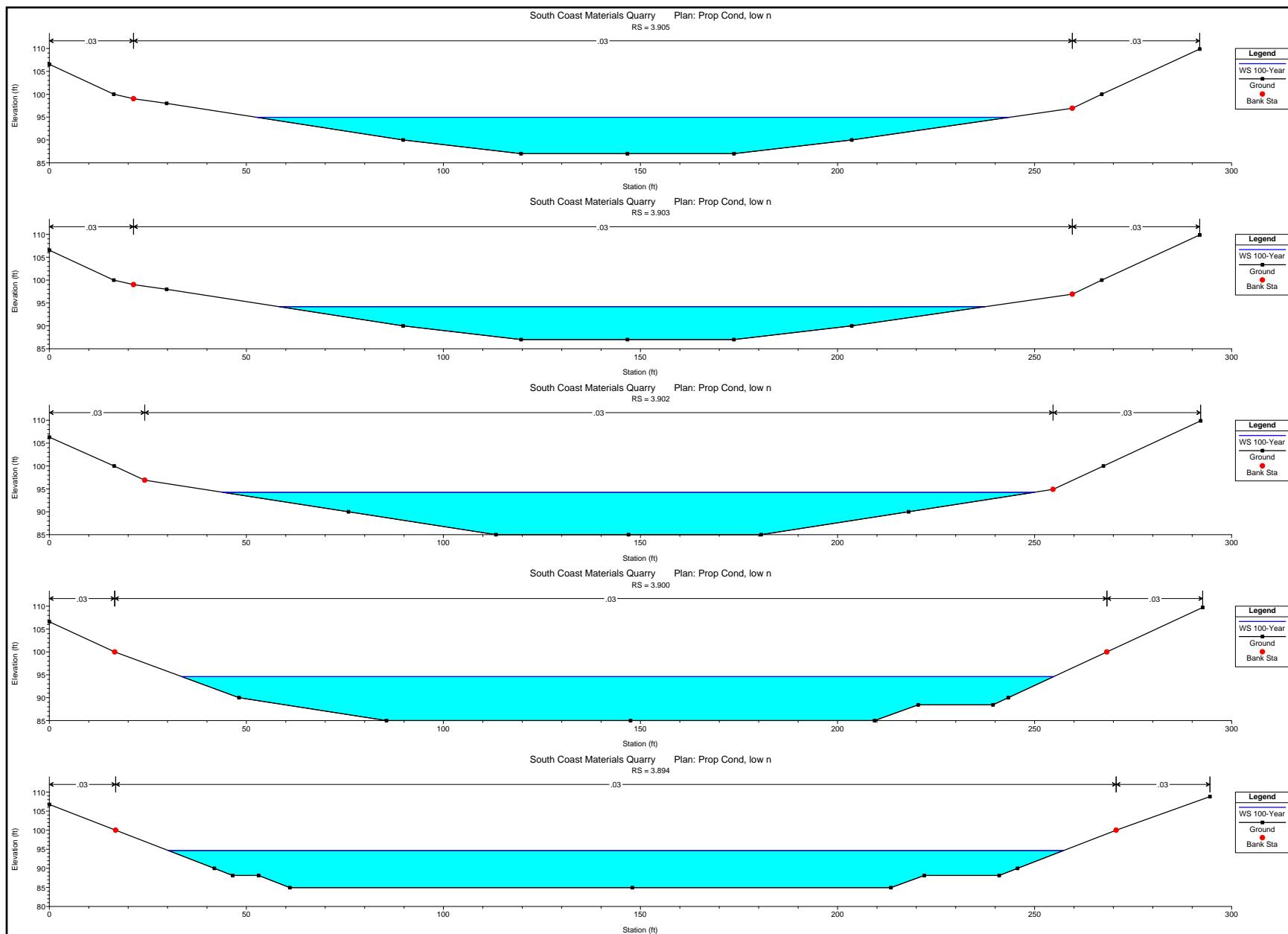
Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	3.902	100-Year	10800.00	85.01	94.25		95.39	0.002677	8.55	1262.90	205.95	0.61
Reach-1	3.903	100-Year	10800.00	87.01	94.19	94.19	96.61	0.007861	12.50	863.84	179.00	1.00
Reach-1	3.905	100-Year	10800.00	87.01	94.96	94.19	96.74	0.005155	10.73	1006.22	190.98	0.82
Reach-1	3.914	100-Year	10800.00	84.00	96.48		96.94	0.000717	5.46	1976.60	228.52	0.33
Reach-1	3.920	100-Year	10800.00	84.20	96.49		96.97	0.000764	5.60	1930.23	226.53	0.34
Reach-1	3.922	100-Year	10800.00	86.12	96.47		96.99	0.000839	5.81	1859.64	223.62	0.35
Reach-1	3.923	100-Year	10800.00	87.00	96.17		97.13	0.002175	7.86	1373.35	216.63	0.55
Reach-1	3.938	100-Year	10800.00	89.40	103.75	103.75	108.24	0.010752	18.17	657.30	110.79	0.95
Reach-1	3.951	100-Year	10800.00	91.00	105.02	105.02	109.62	0.010160	18.52	683.42	106.69	0.95
Reach-1	3.968	100-Year	10800.00	95.20	109.54		110.23	0.001096	6.68	1652.68	180.76	0.33
Reach-1	3.982	100-Year	10800.00	99.90	110.55	110.55	114.80	0.018461	16.79	667.64	81.15	0.97
Reach-1	3.994	100-Year	10800.00	111.80	128.19	128.19	134.66	0.025955	20.42	529.05	41.17	1.00
Reach-1	4.002	100-Year	10800.00	128.00	143.99	143.99	149.09	0.014008	19.76	658.68	69.90	0.92
Reach-1	4.019	100-Year	10800.00	136.50	151.68	151.68	156.80	0.013457	18.93	648.36	67.91	0.88
Reach-1	4.041	100-Year	10800.00	138.00	156.76	153.07	158.09	0.005242	9.84	1187.05	125.22	0.42
Reach-1	4.059	100-Year	10800.00	147.70	159.07	159.07	162.64	0.021998	16.20	739.15	109.91	0.93
Reach-1	4.075	100-Year	10800.00	149.60	162.44		163.70	0.005696	9.65	1221.90	136.99	0.50
Reach-1	4.103	100-Year	10800.00	152.00	163.26		164.81	0.008583	10.82	1118.10	143.15	0.60

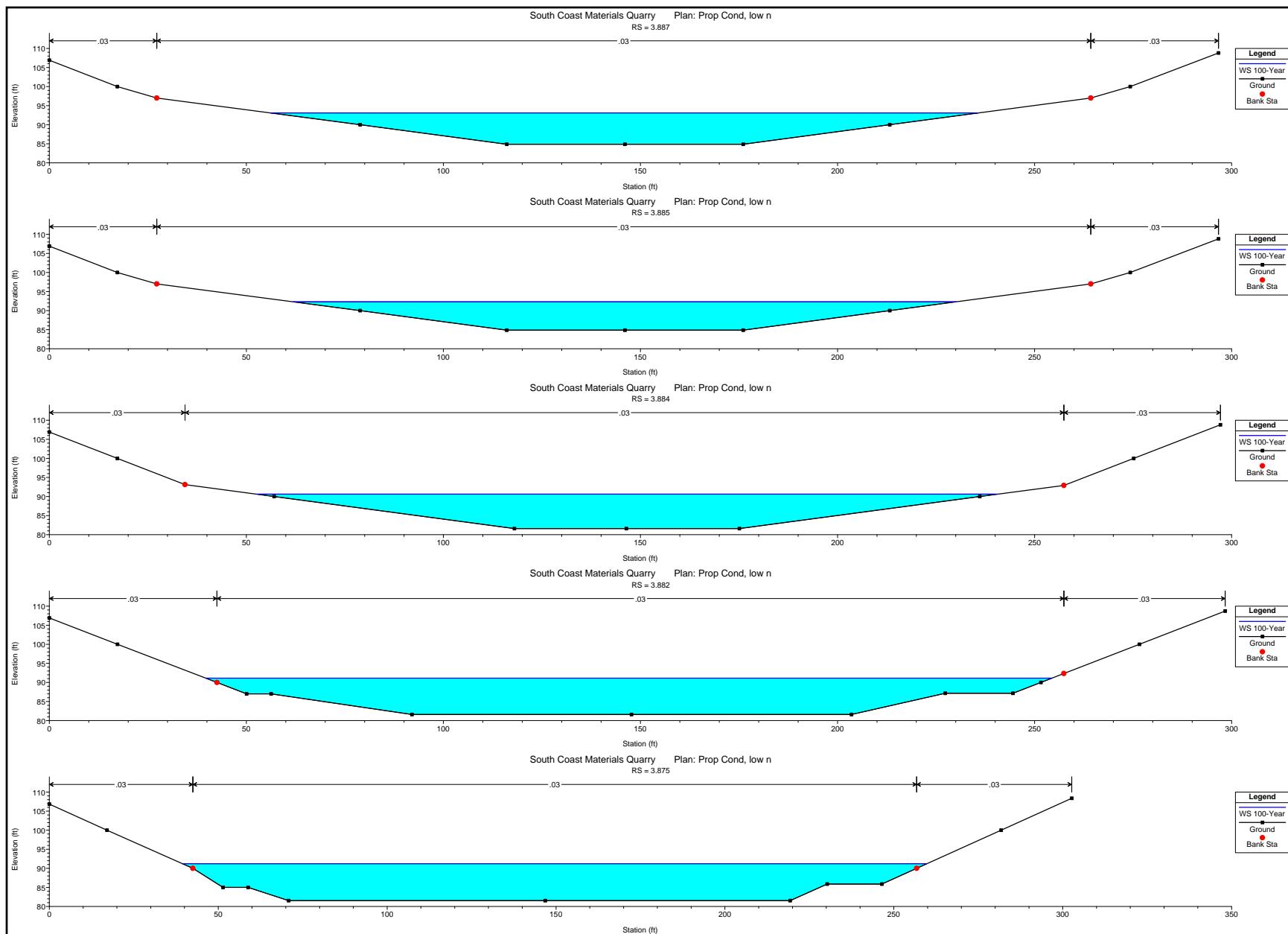


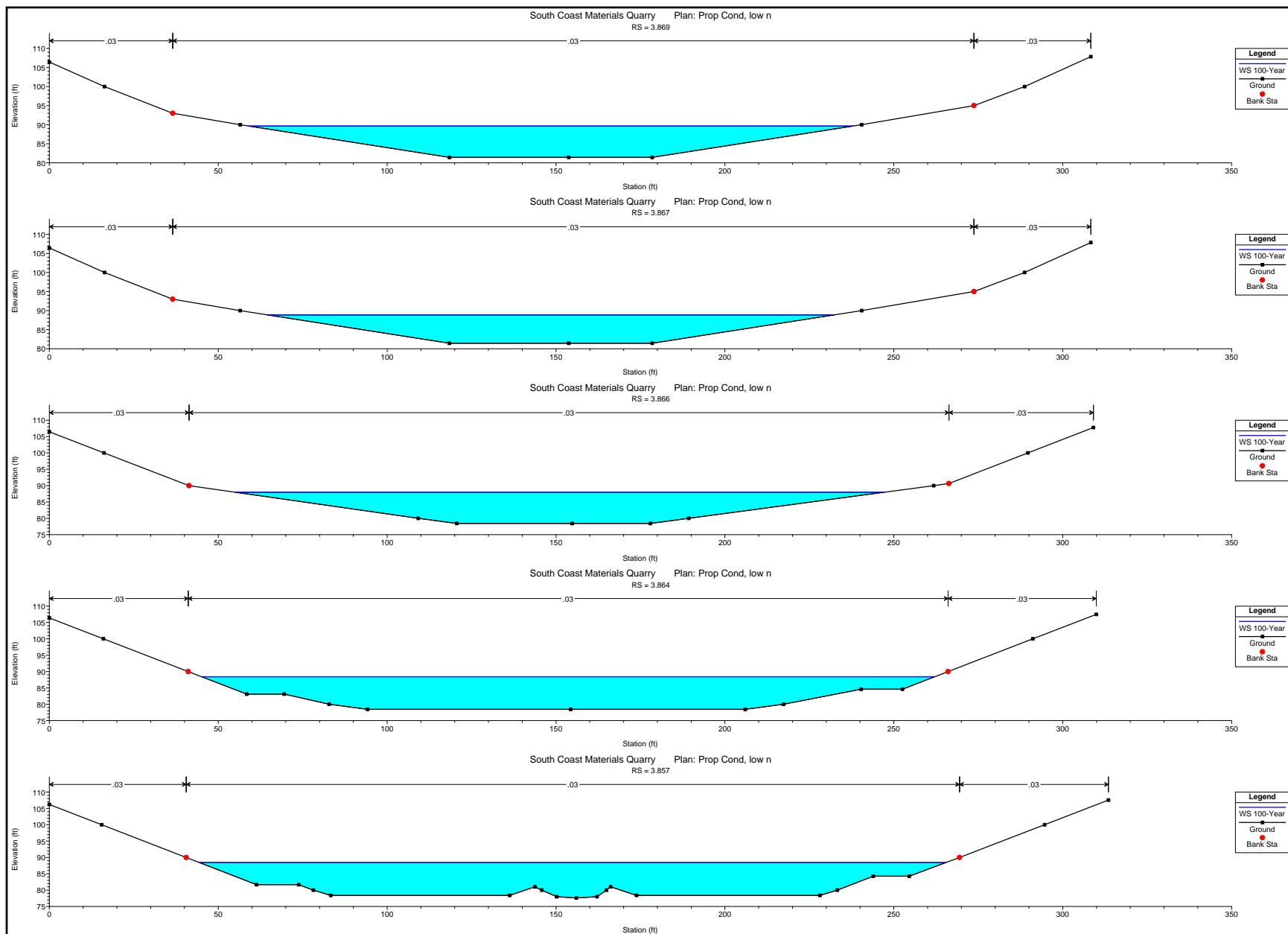


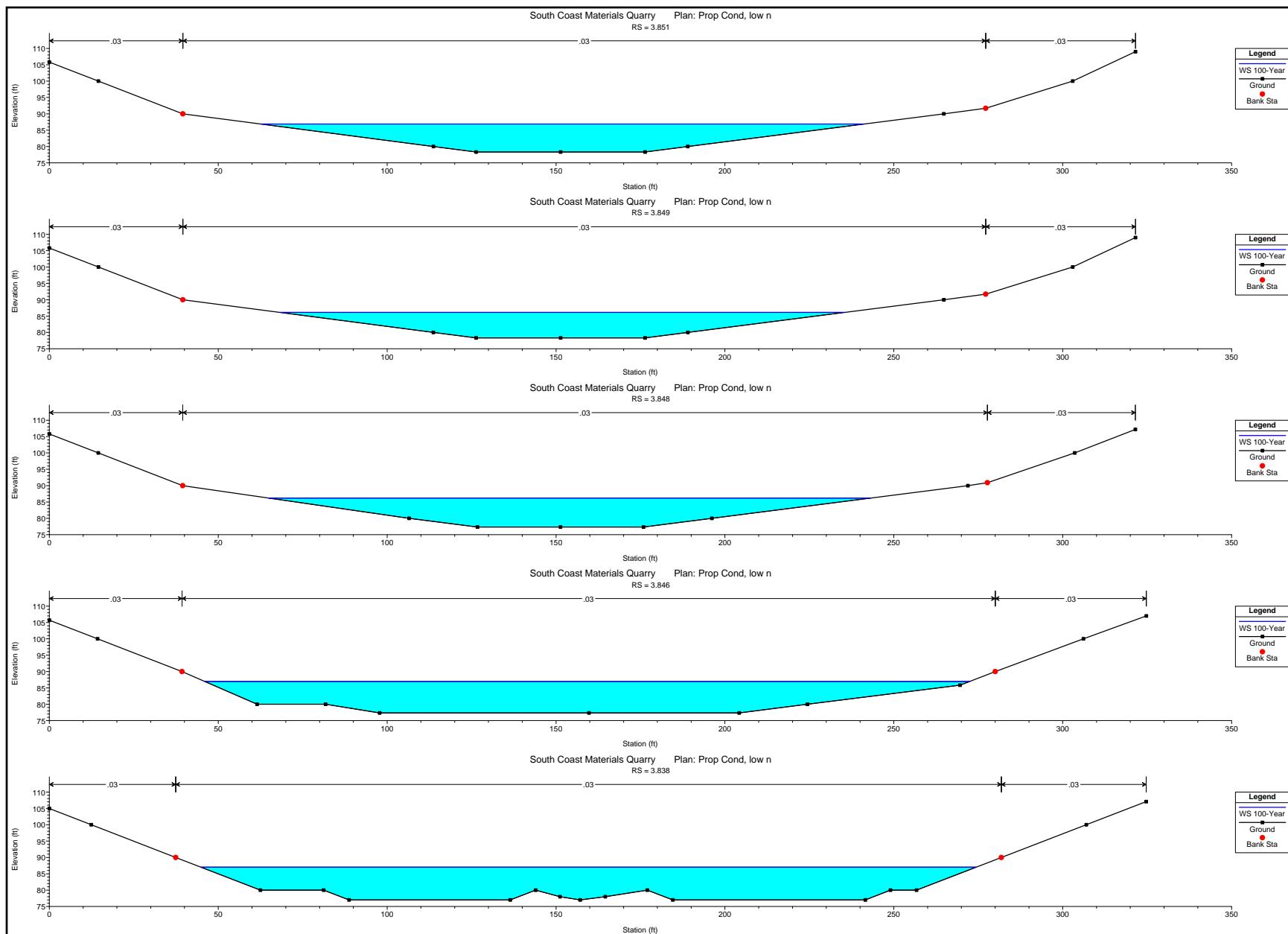


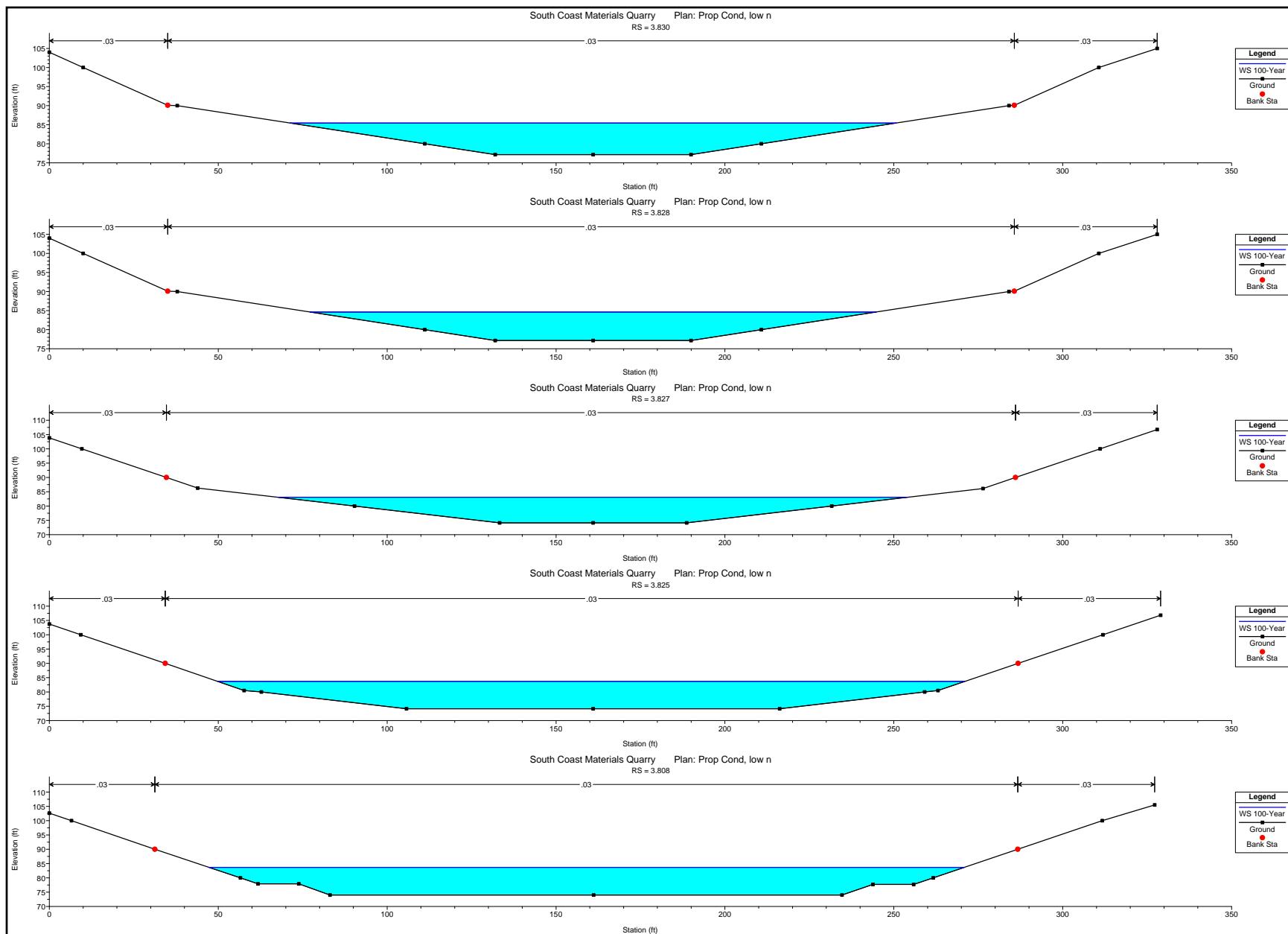


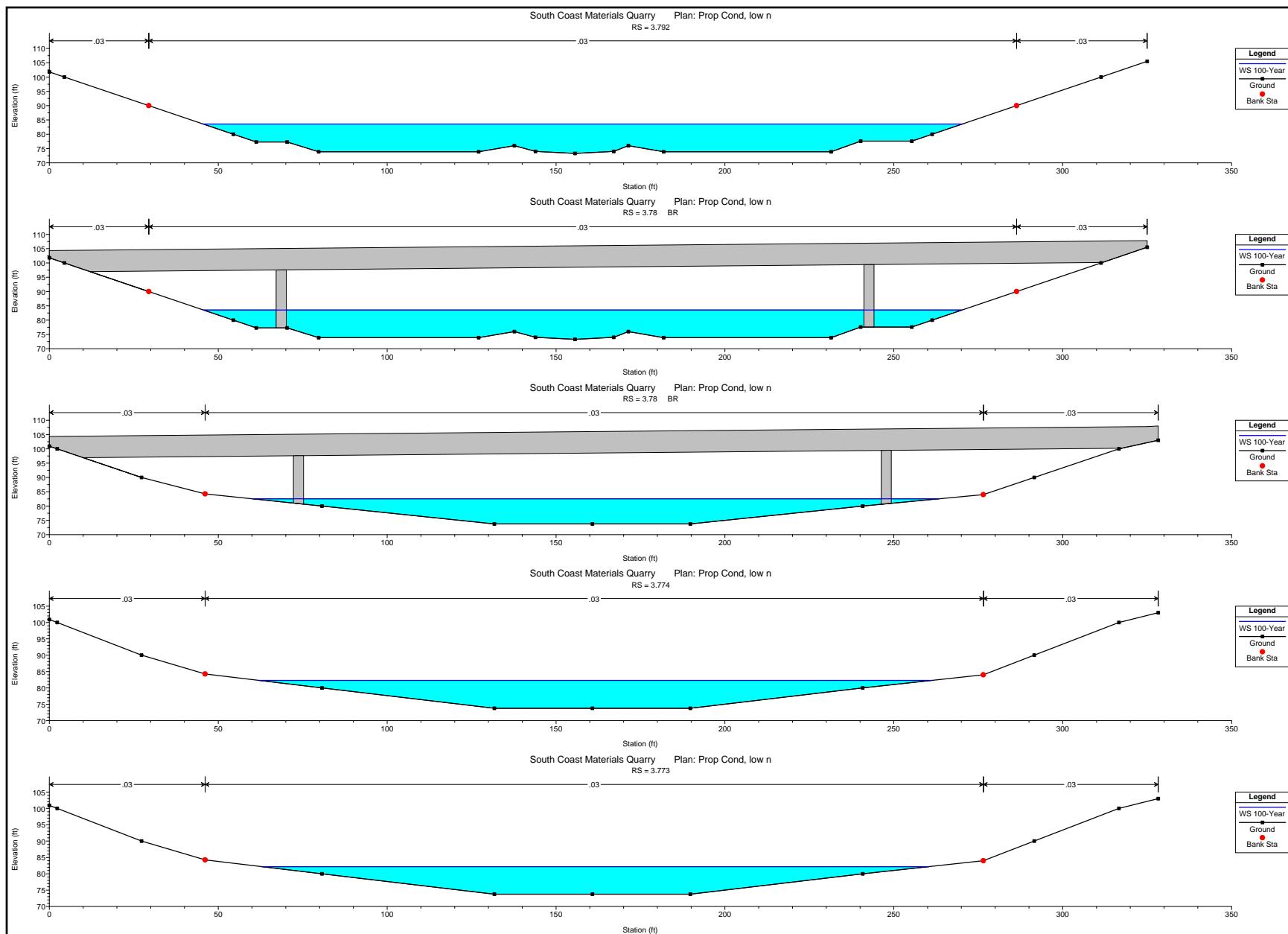


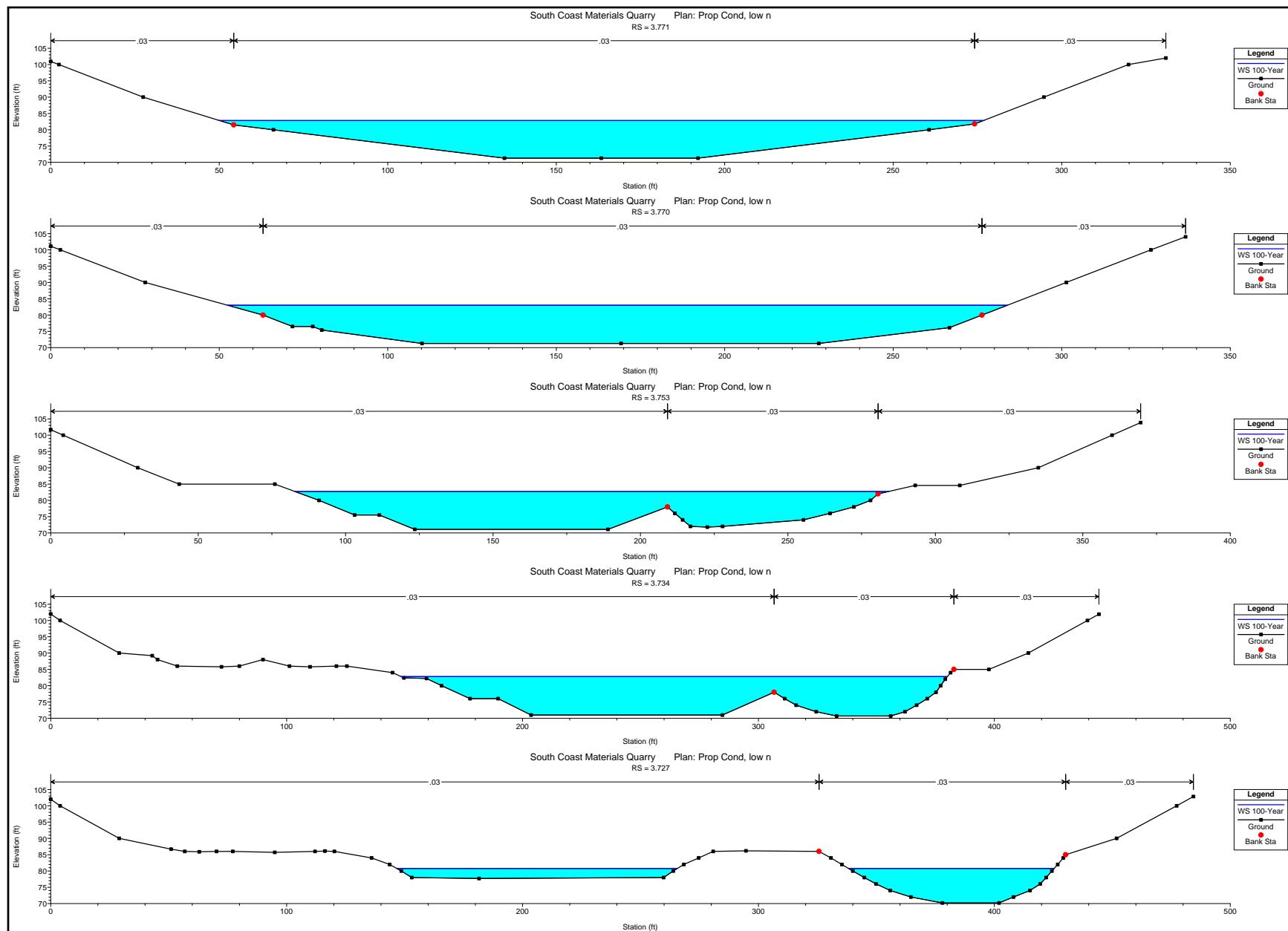


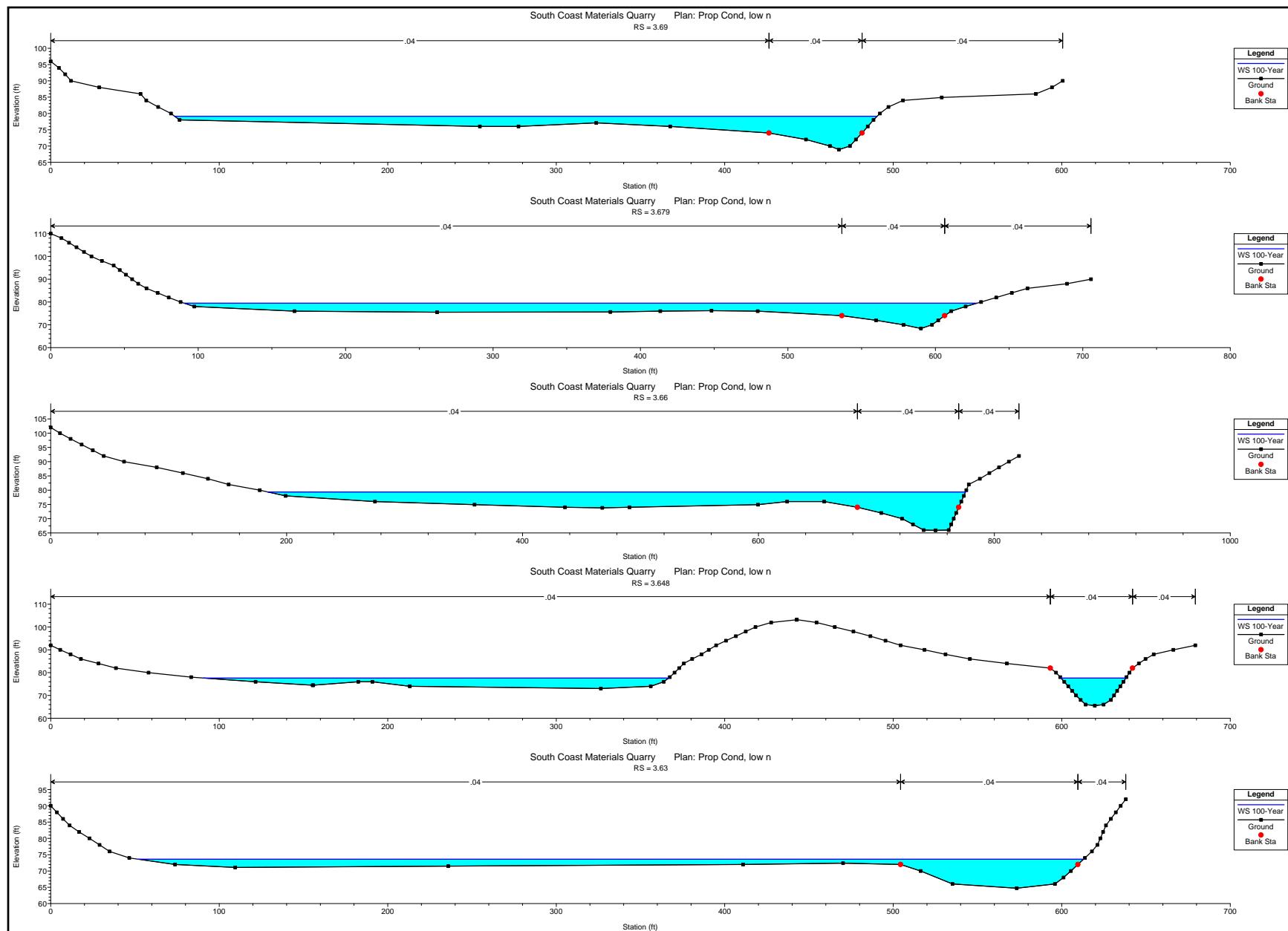


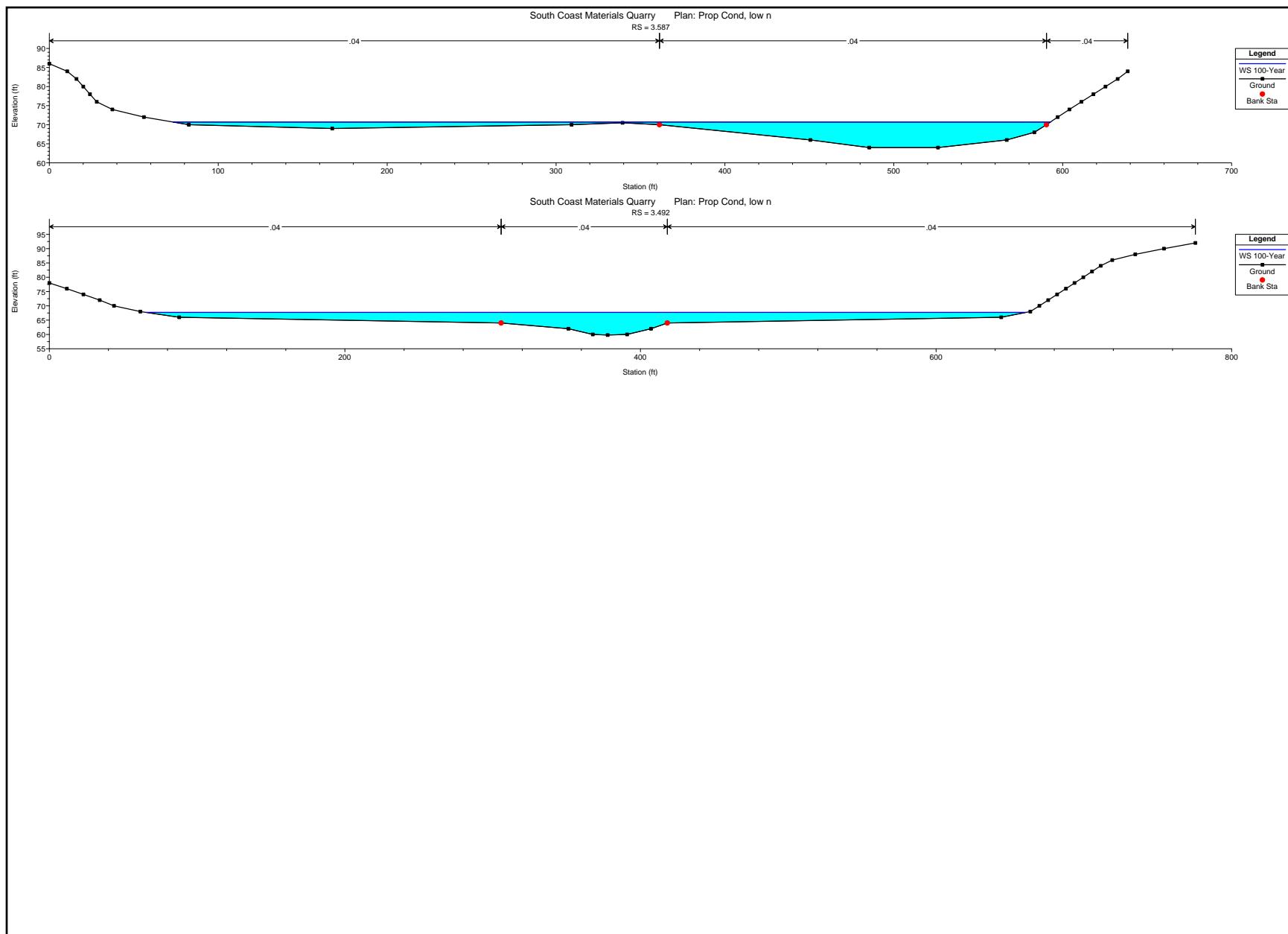












HIGH CHANNEL ROUGHNESS ANALYSIS

HEC-RAS Plan: PC high n River: RIVER-1 Reach: Reach-1 Profile: 100-Year

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	3.492	100-Year	10800.00	59.80	69.33	67.01	69.57	0.004201	4.93	2885.40	618.07	0.32
Reach-1	3.587	100-Year	10800.00	64.00	72.04		72.57	0.009926	6.35	2027.92	541.54	0.47
Reach-1	3.63	100-Year	10800.00	64.70	74.37	73.59	75.01	0.011046	7.85	1975.00	570.06	0.51
Reach-1	3.648	100-Year	10800.00	65.50	77.61	77.61	79.22	0.036558	13.10	1155.11	314.46	0.82
Reach-1	3.66	100-Year	10800.00	65.90	79.97		80.17	0.002543	4.65	3280.67	598.59	0.25
Reach-1	3.679	100-Year	10800.00	68.40	80.38		80.67	0.004331	5.61	2709.64	546.36	0.33
Reach-1	3.69	100-Year	10800.00	68.90	80.71		81.24	0.008009	7.61	2032.67	425.23	0.44
Reach-1	3.727	100-Year	10800.00	70.20	82.19		83.42	0.026542	9.81	1294.23	218.08	0.59
Reach-1	3.734	100-Year	10800.00	70.70	83.55		83.89	0.004920	4.73	2308.50	234.73	0.26
Reach-1	3.753	100-Year	10800.00	71.80	83.99		84.44	0.006339	5.13	2020.29	211.18	0.29
Reach-1	3.770	100-Year	10800.00	71.26	84.48		84.77	0.003197	4.30	2553.88	240.22	0.22
Reach-1	3.771	100-Year	10800.00	71.26	84.43		84.85	0.006375	5.24	2076.45	235.73	0.30
Reach-1	3.773	100-Year	10800.00	73.76	84.24		85.03	0.018963	7.15	1511.15	230.83	0.49
Reach-1	3.774	100-Year	10800.00	73.76	84.47		85.21	0.016843	6.90	1566.49	232.28	0.47
Reach-1	3.78	Bridge										
Reach-1	3.792	100-Year	10800.00	73.30	85.89	79.23	86.22	0.004546	4.57	2361.68	236.33	0.25
Reach-1	3.808	100-Year	10800.00	74.00	86.28		86.58	0.004082	4.43	2436.30	236.68	0.24
Reach-1	3.825	100-Year	10800.00	74.14	86.65		86.97	0.004508	4.58	2355.57	235.87	0.26
Reach-1	3.827	100-Year	10800.00	74.14	86.56		87.11	0.010520	5.94	1817.12	234.18	0.38
Reach-1	3.828	100-Year	10800.00	77.16	86.01		87.54	0.043283	9.93	1087.72	187.76	0.73
Reach-1	3.830	100-Year	10800.00	77.16	86.74		87.94	0.031091	8.79	1228.12	198.42	0.62
Reach-1	3.838	100-Year	10800.00	77.00	88.10		88.49	0.006168	5.02	2150.46	234.89	0.29
Reach-1	3.846	100-Year	10800.00	77.33	88.33		88.78	0.007386	5.35	2020.48	232.90	0.32
Reach-1	3.848	100-Year	10800.00	77.33	88.10		89.05	0.022113	7.83	1379.26	205.27	0.53
Reach-1	3.849	100-Year	10800.00	78.33	87.90		89.23	0.035573	9.24	1168.56	193.86	0.66
Reach-1	3.851	100-Year	10800.00	78.33	88.46		89.57	0.027889	8.45	1278.42	202.18	0.59
Reach-1	3.857	100-Year	10800.00	77.60	89.65		90.06	0.006341	5.12	2107.69	227.14	0.30
Reach-1	3.864	100-Year	10800.00	78.43	89.78		90.23	0.007044	5.35	2018.70	223.88	0.31
Reach-1	3.866	100-Year	10800.00	78.43	89.66		90.43	0.016485	7.03	1536.47	215.67	0.46
Reach-1	3.867	100-Year	10800.00	81.45	88.86	88.86	91.41	0.086737	12.80	843.46	167.51	1.01
Reach-1	3.869	100-Year	10800.00	81.45	90.76		92.05	0.033803	9.10	1187.28	194.13	0.65
Reach-1	3.875	100-Year	10800.00	81.53	92.27		92.70	0.006390	5.28	2054.60	225.73	0.30
Reach-1	3.882	100-Year	10800.00	81.59	92.48		92.99	0.008240	5.70	1899.31	221.53	0.34
Reach-1	3.884	100-Year	10800.00	81.59	92.36		93.21	0.019449	7.42	1455.34	213.27	0.50
Reach-1	3.885	100-Year	10800.00	84.87	92.28	92.28	94.83	0.086977	12.81	843.40	167.83	1.01
Reach-1	3.887	100-Year	10800.00	84.87	94.19		95.47	0.033902	9.07	1190.25	195.79	0.65
Reach-1	3.894	100-Year	10800.00	84.94	95.62		96.03	0.006402	5.12	2109.40	231.95	0.30
Reach-1	3.900	100-Year	10800.00	85.01	95.79		96.24	0.007371	5.39	2005.12	227.97	0.32

HEC-RAS Plan: PC high n River: RIVER-1 Reach: Reach-1 Profile: 100-Year (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	3.902	100-Year	10800.00	85.01	95.70		96.43	0.015767	6.86	1573.92	223.55	0.45
Reach-1	3.903	100-Year	10800.00	87.01	95.19		96.83	0.050666	10.27	1052.01	194.67	0.78
Reach-1	3.905	100-Year	10800.00	87.01	96.08		97.28	0.032880	8.77	1231.17	208.51	0.64
Reach-1	3.914	100-Year	10800.00	84.00	97.48		97.85	0.005687	4.89	2206.81	233.63	0.28
Reach-1	3.920	100-Year	10800.00	84.20	97.67		98.04	0.005681	4.91	2200.72	232.44	0.28
Reach-1	3.922	100-Year	10800.00	86.12	97.71		98.11	0.006065	5.04	2141.00	230.05	0.29
Reach-1	3.923	100-Year	10800.00	87.00	97.61		98.24	0.012762	6.39	1689.08	224.73	0.41
Reach-1	3.938	100-Year	10800.00	89.40	103.68	103.68	108.04	0.036684	17.83	652.48	110.62	0.94
Reach-1	3.951	100-Year	10800.00	91.00	107.08		109.68	0.013542	12.70	845.89	117.90	0.60
Reach-1	3.968	100-Year	10800.00	95.20	109.79		110.44	0.003559	6.50	1686.20	181.51	0.32
Reach-1	3.982	100-Year	10800.00	99.90	110.55	110.55	114.80	0.018461	16.79	667.64	81.15	0.97
Reach-1	3.994	100-Year	10800.00	111.80	128.19	128.19	134.66	0.025955	20.42	529.05	41.17	1.00
Reach-1	4.002	100-Year	10800.00	128.00	143.99	143.99	149.09	0.014008	19.76	658.68	69.90	0.92
Reach-1	4.019	100-Year	10800.00	136.50	151.68	151.68	156.80	0.013457	18.93	648.36	67.91	0.88
Reach-1	4.041	100-Year	10800.00	138.00	156.76	153.07	158.09	0.005242	9.84	1187.05	125.22	0.42
Reach-1	4.059	100-Year	10800.00	147.70	159.07	159.07	162.64	0.021998	16.20	739.15	109.91	0.93
Reach-1	4.075	100-Year	10800.00	149.60	162.44		163.70	0.005696	9.65	1221.90	136.99	0.50
Reach-1	4.103	100-Year	10800.00	152.00	163.26		164.81	0.008583	10.82	1118.10	143.15	0.60

